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The PRACTICAL MAGAZINE:

AN ILLUSTRATED CYCLOPÆDIA OF

INDUSTRIAL NEWS, INVENTIONS AND IMPROVEMENTS,

COLLECTED FROM

Foreign and British Sources,

FOR THE USE OF

THOSE CONCERNED IN RAW MATERIALS, MACHINERY, MANUFACTURES, BUILDING, AND DECORATION,

PARTICULARLY OF

Manufacturers—Textile, Ceramic, and Chemical.
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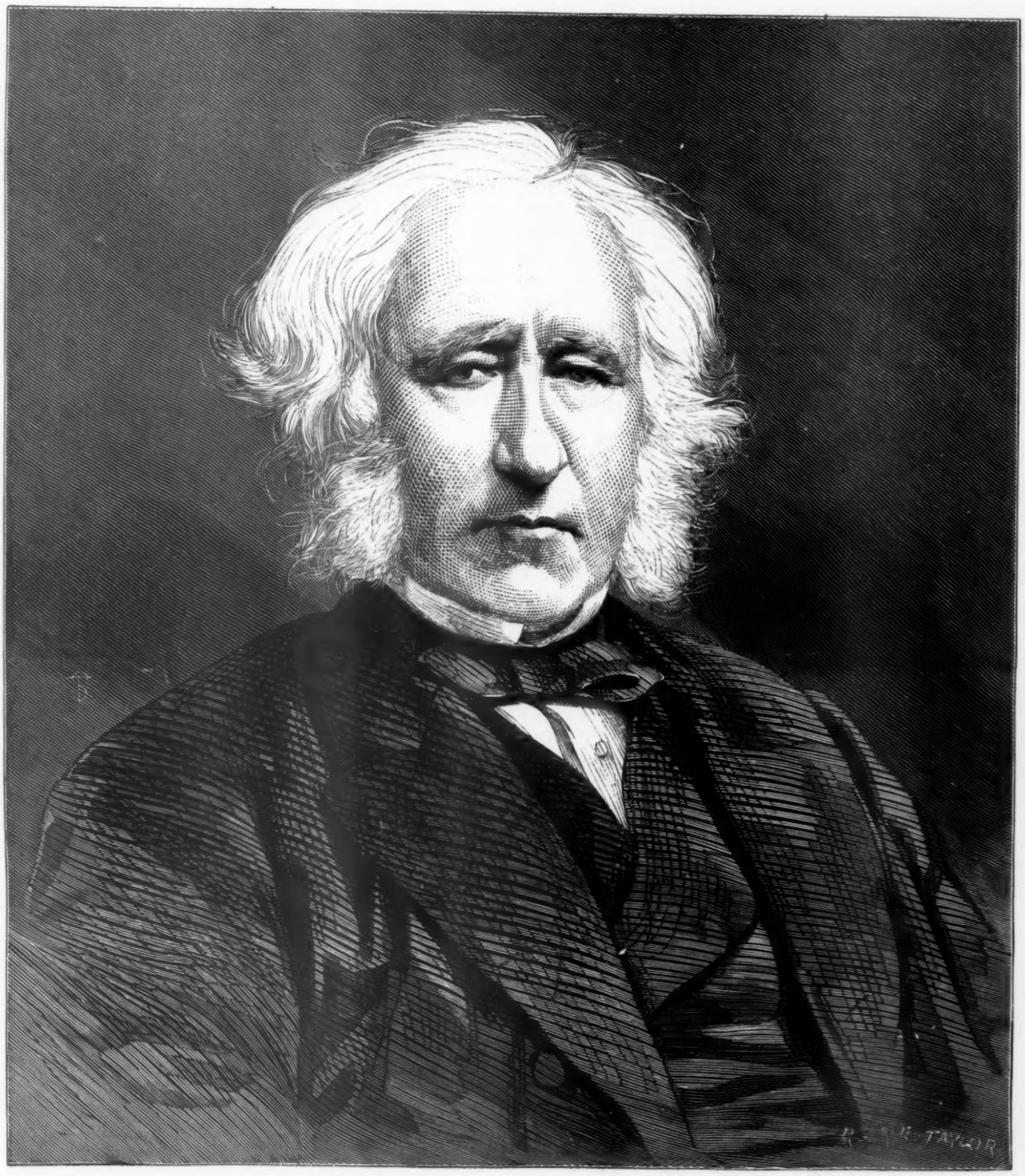


ROBERT NAPIER, ESQ. (OF GLASGOW.)

THE SHIPBUILDING TRADE OF THE CLYDE.

MARINE architecture owes more to the Clyde than to any other river. The cradle of steam navigation, it has also and always taken the lead in the various improvements that have brought about the present perfect condition of the art of shipbuilding. It is worthy of being remembered that the Clyde has taken up its leading position in regard to naval architecture, not because, but in spite of its natural facilities for this purpose. Originally a petty, tortuous streamlet, full of rock-beds, fords, and shallows, it has, by an expenditure of energy, engineering skill, and capital, such as have been bestowed upon no other river, become one of the noblest highways of commerce, adapted to all the exigencies and ends of navigation, and contributing more than aught else to the prosperity of a city "whose merchants are princes and whose traffickers are the honourable of the earth."

The shipping of Glasgow harbour is quoted by Captain Slezer in his "Theatrum Scotiæ" of 1670 as only consisting of three fishing boats of ten tons each. In 1754, when James Watt came to the city, the Broomielaw was only a petty harbour, not more than 262 yards in length. Fourteen years later, we have it on record that the river was crossed by seven fords. One of these was as far down as Dumbuck, 12 miles from Glasgow, where there was only a depth of 2 ft. at low water. There are those still alive who can remember crossing the Clyde on foot a little below the Broomielaw. It was thought a great achievement when, in 1801, craft of 40 tons burden arrived at Glasgow; and a good story is told of one Sandy Lindsay, of Loch Lomond, who about this time built a vessel of 30 tons burden for the purpose of exploring "the wee bit burn ca'd the Clyde," and who, on reaching the Broomielaw, was presented with the freedom of the city for his exceptional daring.

Under the control of the Navigation Trustees, the Clyde was deepened, widened, and otherwise adapted to the purposes of commerce, until, in 1821, vessels drawing 13 ft. of water could come up to the Broomielaw, and since then successive improvements have not only enabled the river to bear on its bosom the largest merchantmen afloat, but have made the Broomielaw one of the most capacious and busy harbours in the world. The following statement of the progress of the river dues, from their first imposition in 1770, will enable the reader to judge of the graduated development of the shipping trade of the port of Glasgow:—

The tonnage and harbour dues for the year	£	s.	d.
1771 were	1,071	0	0
1791	2,145	0	0
1804	4,760	0	0
1815	5,960	0	0
1825	8,480	0	0
1826 (when 33 per cent. were added to the rates) .	16,200	0	0
1828	17,669	0	0
1830	20,296	0	0
1832	22,496	0	0
1834	22,859	0	0
1835	31,900	0	0
1836	35,612	0	0
1837	35,595	0	0
1838	37,028	0	0
1839	45,826	0	0
1840	46,446	1	9

In the latter year, the number of vessels belonging to the port of Glasgow was 431, their aggregate tonnage being no more than 95,619 tons. There are now over 900 vessels belonging to the port, with an aggregate burden of nearly 500,000 tons. It is needless to add that the tonnage and harbour dues have correspondingly increased.

It will be seen, then, that the Clyde in its primitive aspects was ill-adapted for the uses and ends of commerce. Of shipping it was virtually destitute, and its shipbuilding trade, at the commencement of the present century, was confined to the construction of a few small gabberts or fishing craft. Until the river was deepened and improved by the Navigation Trustees, any extensive development of the shipbuilding trade was impossible. But the same skill and energy that transformed the Clyde from a shallow and brawling streamlet to a noble and navigable river, has reared on its banks the largest shipbuilding trade in the world. The shipping and shipbuilding of the Clyde have grown together with such an even pace that the one might be fitly described as the natural evolution of the other. Collaterally, therefore, an allusion to the primitive aspects of the river, and its insignificance and lack of suitability for all the purposes of commerce, was necessary to enable the reader to understand and appreciate the magnitude of the difficulties which have been surmounted in establishing the industry upon the consideration of which we now enter.

It is no part of our purpose to inquire into the disputed claims of Mr. Miller of Dalswinton, Mr. Symington of Falkirk, Mr. Robert Fulton, or Lord Stanhope, in reference to the initial application of steam navigation. It is now generally admitted that whatever efforts these gentlemen may have made in the same direction, Henry Bell was the first who successfully applied steam to the propelling of vessels against wind or tide. The Clyde, therefore, lays just claim to the honour of being the cradle of steam navigation. It was in 1811 that the now historical "Comet" was built by Messrs. John Wood and Co. of Port Glasgow, under the directions of Bell; and on the 18th January, 1812, the vessel made her first voyage from Glasgow to Greenock. It was thought a great achievement when she made five miles an hour against a head wind. Unfortunately, Bell either had not the means or was too simple-minded to take out a patent for his invention, so that it speedily came to be copied on an extensive scale. Four years after the "Comet" begun to ply on the Clyde, Mr. James Cleland writes in his "Annals of Glasgow," that "Mr. Bell continued to encounter and overcome the various and indescribable difficulties incident to invention, till his ultimate success encouraged others to embark in similar undertakings, which has been done in a ratio only to be credited by the knowledge of the number of vessels which have been placed on the river [the Clyde]. Owing to the novelty and supposed danger of passage in the Forth below Dumbarton, in vessels which had so small a hold of the water, the number of passengers at the outset was but small. The public, however, having gained confidence by degrees in a navigation which became at once expeditious and pleasant, it was preferred to every other mode of conveyance; for the expedition of the voyage, and the beauty of the scenery on the banks of the Clyde, are such as to attract alike the attention of the man of business and pleasure; and the watering-places all along the coast have been crowded with company beyond all former precedent, in consequence of steam conveyance. It has been calculated that, previous to the erection of steamboats, not more than fifty persons passed and repassed from Glasgow to Greenock in one day; whereas it is now supposed that there are from four to five hundred pass and repass in the same period. The passage between Glasgow and Greenock is about twenty-six miles, and is usually performed in three hours; and often when the wind and tide are favourable, it is performed in less than two hours and a-half." The steamboats first constructed on the Clyde were propelled by two paddle-wheels, constructed after the model of the old undershot water-mill wheels. In some boats they were placed at right angles to their sides, in others they were fitted in a circular direction, while in others, again, an oblique form was adopted. The tabulated statement on the opposite page is taken from Cleland's work, which is now exceedingly rare, and may be relied upon for its accuracy.

Although it was a good deal discredited on its *first* application, and although superstition and unbelief tried hard to re-establish the old order of things, by persuading gullible people that steam-navigation was not "canny," that it was an invention of the Evil One, and that those who encouraged it would surely come to grief, an invention that possessed so much inherent merit made progress rapidly, and in less than four years after the "Comet" commenced to ply on the Clyde, steam-boats could be found on the Forth, the Tay, the Avon, the Severn, the Thames, the Tyne, the Yare, the Trent, the Mersey, the Orwell, the Humber, and the Ouse. Many will share our regret when we add, that while Fulton, who was the first to apply steam to the propulsion of vessels in America, was loaded with wealth and honours, Bell was compelled to endure obscurity and comparative penury till the close of his life, his only source of subsistence being a pittance of £50 per annum, granted to him by the Trustees of the Clyde Navigation. The "Comet" was lost on the Doors of Dorrismore, but according to the "Parliamentary Gazeteer of Scotland," "her engine was fished up and placed as a most interesting relic in the establishment of Claud Girwood and Co. This prototype of those engineering triumphs which we now see in every harbour was placed in the model-room during the sitting of the British Association [at Glasgow in 1840], adjacent to the tiny engine upon which Watt experimented, and attracted the greatest attention."

The next most important advance in steam-navigation was the employment of steam-propelled vessels on the open sea. It was supposed at first that steam-vessels were only capable of navigating the smooth waters of lakes or rivers, and their operations were in fact thus far limited until Mr. David Napier, of Glasgow, built the "Rob Roy," a steamer of about 90 tons burden and

30-horse power, for the purpose of carrying on a trade between Glasgow and Belfast. This venture was eminently successful. The "Rob Roy" performed her appointed voyages during the winter as well as during the summer months, and thus demonstrated that steam vessels were quite as safe as sailing ships for ocean-going purposes.

LIST AND DESCRIPTION OF STEAMBOATS PLYING ON THE RIVER CLYDE IN THE YEAR 1816. (See *ante*, p. 2.)

No.	Name.	When Launched.	Length of Keel.	Length of Beam.	Carpenter's Name and Residence.	Size of Engine.	Engine Maker's Name and Residence.
			feet	ft. in.			
1	Comet	Jan. 1812	38	11 6	Jn. Wood & Co. Port-Glasgow	6 horse-power	Henry Bell, Glasgow
2	Elizabeth	Nov. 1812	40	12	Jn. Wood & Co. Port-Glasgow	10 horse-power	Jn. Thomson & Co. Tradestown, Glas.
3	Clyde	Feb. 1813	68	14	Jn. Wood & Co. Port-Glasgow	10 horse-power	John Robertson, Glasgow
4	Glasgow	Sept. 1813	60	15	Jn. Wood & Co. Port-Glasgow	14 horse-power	Henry Bell, Glasgow
5	Trusty	Feb. 1814	65	16	John Denny, Dumbarton	10 horse-power	George Dobbie, Tradestown, Glasgow
6	Princess Charlotte	March 1814	65	10 6	James Munn, Greenock	2 engines, each 4 horse-power	Bolton, Watt, & Co. Soho
7	Industry	May 1814	65	16	——— Fairlie	10 horse-power	George Dobbie, Tradestown, Glasgow
8	Prince of Orange	June 1814	64	12	James Munn, Greenock	2 engines, each 4 horse-power	Bolton, Watt, & Co. Soho
9	Argyle, 1st	June 1814	72	14 6	Alex. Martin & Co. Port-Glasg.	14 horse-power	James Cook, Tradestown, Glasgow
10	Margery	June 1814	56	12	John Denny, Dumbarton	10 horse-power	James Cook, Tradestown, Glasgow
11	Britannia	Jan. 1815	80	16 8	John Hunter, Port-Glasgow	24 horse-power	Dun. M'Arthur & Co. Camlachie, do.
12	Dumbarton Castle	Feb. 1815	84	16 8	John Denny, Dumbarton	30 horse-power	Dun. M'Arthur & Co. Camlachie, do.
13	Caledonia	April 1815	86	15	Jn. Wood & Co. Port-Glasgow	2 engines, each 18 horse-power	Greenhead Foundry Company, do.
14	Greenock	May 1815	80	16 8	John Denny, Dumbarton	32 horse-power	Dun. M'Arthur & Co. Camlachie, do.
15	Argyle, 2nd	July 1815	72	15	Jn. Wood & Co. Port-Glasgow	20 horse-power	Greenhead Foundry Company, do.
16	Waterloo	Jan. 1816	72	16	John Hunter, Port-Glasgow	20 horse-power	James Cook, Tradestown, do.
17	Neptune	Feb. 1816	68	15 5	Jn. Wood & Co. Port-Glasgow	20 horse-power	Dun. M'Arthur & Co. Camlachie, do.
18	Lord Nelson	Feb. 1816	71	16	Jn. Wood & Co. Port-Glasgow	20 horse-power	Greenhead Foundry Company, do.
19	Albion	March 1816	73	16	Jn. Wood & Co. Port-Glasgow	20 horse-power	James Cook, Tradestown, do.
20	Rothsay Castle	April 1816	76	16 6	John Denny, Dumbarton	34 horse-power	Dun. M'Arthur & Co. Camlachie, do.

It cannot be claimed for the Clyde that the use of iron for shipbuilding purposes was commenced on that river. In 1818, however, the passenger-boat, the "Vulcan," was built by Mr. Robert Wilson for the Forth and Clyde Canal Company; and, as this was the first vessel built of iron in Scotland, the builders found considerable difficulty in carrying out Mr. Wilson's plans. He says, in a letter which he wrote to a friend with reference to the building of the "Vulcan," "There was no angle iron in those days, nor any machinery excepting an old-fashioned piercing-machine, a cast-iron grooved block to form the ribs, and a smith's fire, and one foot knee'd at a heat, was considered good work." The "Vulcan" was designed by the late Sir John Robinson, of Edinburgh, and she was still doing duty a few years ago, as well as ever. It is somewhat remarkable that several patents for improvements in the construction of iron ships were cancelled when the keel of the "Vulcan" was examined. It was not, however, until 1838 that iron was used for the hull of a vessel of any size, so that the change from timber to the more durable material was slowly accomplished. Messrs. Tod and M'Gregor, of Glasgow, constructed the "Royal Sovereign" in this year for the trade between Glasgow and Liverpool. As usual, there were wiseacres who predicted that an iron vessel of such a size would prove a complete failure. But the event did not justify any such predictions. On the contrary, the practicability, safety, and economy of iron steam-ships were fairly solved by the builders of the "Royal Sovereign," who in six months afterwards launched the "Royal George" for the same trade, and afterwards the "Princess Royal" came from their hands. But it was one thing to send an iron vessel on a coasting voyage, and it was quite another thing to commit her to the dangers and vicissitudes attendant on ocean going. The first steam-ship that crossed the Atlantic was the "Savannah," which in 1819 made the passage from New York to Liverpool in twenty-six days. It was not, however, until 1838 that a steam-vessel belonging to Great Britain attempted the voyage—not because it was believed that the application of steam on such a voyage was impracticable, but because an impression prevailed that steamers could not be profitably employed on an Atlantic voyage, in consequence of the immense proportion of carrying space and power required for the coal consumed on the journey. The greatest authorities of the day in all that related to scientific advancement pointed the finger of ridicule at the idea of employing steam-vessels for such a purpose. Dr. Lardner himself is reported to have said in a lecture delivered in Liverpool in 1835, that the project of making the vogage direct from Liverpool to New York was perfectly chimerical, and that they might as well talk of making a voyage to the moon. Since then marine architecture has become a much more perfect science, and the use of compound engines, the construction of a swifter class of vessel, and other aids to economical and rapid navigation, have not only rendered an Atlantic steam-voyage an event of every day occurrence, but have led to the substitution of steam for sailing vessels in the great Pacific Ocean, an ocean which covers a larger area than all the dry land on the habitable globe, and in the navigation of which we witness the full advantage and importance of steam navigation to the interests of civilization and commerce.

The next link in the chain which has indissolubly bound up the history of the Clyde with that of the progress of marine architecture was the application of the screw as a means of propulsion. We believe that the first vessel built with a screw propeller instead of paddles was the "Archimedes," so named from the novelty of using the principle of the Archimedean screw as a means of motion. The "Archimedes" was built in London in 1840 for a Liverpool firm, and in a race on the Mersey beat two of the swiftest paddle-boats then built—the mail tender "Redwing," and one of the Egremont new iron boats. The shipping trade was not long in giving its confidence to the principle of the screw propeller. Within a few years after the "Archimedes" came forth, "a thing of beauty," from the hands of her builders, a considerable number of screw steamers were built. But until the year 1850 it was deemed too hazardous an experiment to employ them in ocean voyages, and they were therefore chiefly used for the coasting trade. In that year, however, the late Mr. David Tod, of Glasgow, founded the Liverpool, New York, and Philadelphia Steamship Company, with the object of establishing a regular communication between Great Britain and America by means of iron steamers screw-propelled. This gentleman built, at his own cost and risk, the screw steamer "City of Glasgow," which was successful in accomplishing several voyages to and from New York between April and November, 1850. In the latter month the "City of Glasgow" passed into the hands of the Liverpool, New York, and Philadelphia Steamship Company, under whose flag she accomplished the first voyage ever made by a screw steamer across the North Atlantic Ocean in the winter season, sailing from Liverpool on the 17th of December, 1850, and, after her return, on the 12th of February in the following year. For some time subsequently to this date none of the ocean mail packets from Liverpool were propelled by screws. The Peninsular and Oriental Steamship Company was the first to follow the lead of the Liverpool, New York, and Philadelphia Steamship Company. The Peninsular and Oriental Company having failed to negotiate the purchase

of the "City of Manchester," which Messrs. Tod and Macgregor built in 1851 for the former company, contracted for the building of the screw steamer "Bengal," which was constructed, with one or two modifications, from the lines of the "City of Manchester." The Peninsular and Oriental Company have since then had nearly all their vessels screw-propelled, and their example has been generally followed by all the leading steamship companies, not only of this, but of all other countries. Thus, to quote from an article that appeared in the Liverpool "Journal of Commerce" in 1865, "a great and beneficial revolution in steam navigation has been effected through the ingenuity of Mr. Tod and the enterprise of the Liverpool, New York, and Philadelphia Steamship Company, a revolution which promises at no distant date to antiquate, if not entirely supersede, the use of ocean-going paddle-wheel steamers, and which, in the estimation of some, not generally regarded as over-sanguine people, will completely supplant the use of ships entirely sail impelled."

Probably the next most important advance in marine architecture, after those above mentioned, was the successful application of the compound steam-engine to the propulsion of vessels. This improvement, in its most perfect form, is also claimed for the Clyde. The late able professor of engineering in Glasgow University—W. J. Macquorn Rankine—says on this subject, "It results from the history of marine steam engineering, that previous to the formation of the firm of Randolph, Elder, and Co. (in 1852), the steam-engine had not been successfully applied in Great Britain to the propulsion of vessels; that compound engines such as Cradock's had been proposed for that purpose, but had not been designed so as fully to realize the advantages of that form of engine; that the abandonment of the steam jacket in the practice of almost all marine engineers had made it useless, if not wasteful, to employ those high rates of expansion to which the compound engine is suited; and that as this practical error originated in an erroneous theory of the mechanical action of heat, founded on the hypothesis of substantial caloric then universally prevalent, it was not to be expected that it should be reformed except by an engineer who had studied and understood the then almost new science of thermodynamics. Such an engineer was Mr. Elder." It was this Mr. Elder who, conjointly with his partner, Mr. Charles Randolph, brought the compound engine to its present high perfection. The improvements introduced by the firm of Randolph, Elder, and Co. in marine engineering have been secured by a series of fourteen patents, nearly all of them relating to different arrangements of the compound marine engine. The first vessel which this firm fitted with compound engines was the screw-steamer "Brandon;" and at her trial trip in July, 1854, the rate of consumption of coal was found to be about 3¼ lbs. per indicated horse-power per hour. The lowest rate of consumption of coal in steamers previous to that time was from 4 lbs. to 4½ lbs. per indicated horse-power per hour. The next ships furnished with compound engines was the "Inca," built in May, 1856, and the "Valparaiso," started in July, 1856, for the Pacific Steam Navigation Company. In the "Inca," the rate of consumption of coal was found to be 2½ lbs. per indicated horse-power per hour; and in the "Valparaiso" the consumption was 3 lbs. In October, 1856, the "Callao," built by Messrs. John Reid and Co., of Port Glasgow, made her trial trip, when the rate of consumption of coal only amounted to 2·7 lbs. per indicated horse-power per hour, a degree of economy never before realized in marine engines; and this, we are told, "was not only obtained on the trial trips of these vessels, but maintained during many years' subsequent service at sea." It amounted to a saving of from 30 to 40 per cent. of the coal previously burned by steamers of the same class; and it is not too much to say that it was this saving which rendered it practicable to carry on steam navigation on the Pacific Ocean with a profit.

The success of the use of the compound engine, as demonstrated on the Clyde by Messrs. Randolph, Elder, and Co., led to the speedy substitution of this for all other forms of the steam-engine in vessels intended to run long voyages. The inventors have during subsequent years constructed many steamers in which the more complete fulfilment of the conditions of the compound engine—a higher initial pressure, a greater rate of expansion, and a greater proportion of superheating surface—has led to still greater economy, the regular consumption of fuel in these vessels ranging from 2¼ lbs. to 2¼ lbs. per indicated horse-power per hour. It is the compound engine, and the compound engine alone, that has made the Pacific Steam Navigation Company—the largest steamship company in the world—what it is. The operations of this company embrace within their ample range the whole of that vast ocean from which it takes its name. Not only does the company maintain a regular line of steamers between Liverpool and Valparaiso, but they have a fleet of more than thirty steamers plying between different stations on the Pacific coast. The Pacific Company are not alone indebted to the compound engine for the success of their operations; they have shared that success with other companies of less pretensions.

No inventions or improvements connected with or affecting marine architecture are at all comparable with those of the initial application of steam to navigation, the construction of ships of iron, the use of the screw propeller, and the substitution of compound for other engines. In each of these leading and essential stages of improvement the Clyde stands out more conspicuously than any other river. But there are numerous minor and collateral improvements devised and perfected on the Clyde, upon which we cannot now comment with the meagre space at our disposal. There is, for example, the patent obtained by Mr. Robert Duncan, shipbuilder, Port Glasgow, for supplying sailing vessels with auxiliary steam-power, to carry them through those latitudes where calms prevail on voyages to the East Indies, China, and Australia. This auxiliary is a steam launch, which is carried on board the sailing vessel so long as the winds are favourable; but on entering a calm region steam is got up in the launch, and she is sent to do duty as a tug alongside the vessel. The first vessel furnished with an aid of this kind was the ship "Niagara," of Port Glasgow, which sailed for Melbourne from the Clyde in Sept., 1867. Clyde "clippers" are known all the world over. Some Clyde builders have obtained a celebrity for composite ships, the Messrs. Stephen, of the Linthouse Shipbuilding Works, taking the lead in this direction, while others, including most notably Messrs. W. Simmons and Co., of Renfrew, and Messrs. Thomas Wingate and Co., of Whiteinch, make a speciality of dredging-machines and hopper-barges.

It now behoves us to furnish statistical information respecting the progress of the shipbuilding industry of the Clyde. Figures are proverbially dry; but to the political economist or man of science, no romance that ever was penned contains more curious or more interesting matter than we are now about to impart. The industrial history of Great Britain contains, probably, no chapter that can be compared with that of which we are now tracing the lines. Not that there is no parallel to the growth of the shipbuilding trade in point of its magnitude, for the development of the iron trade in the Cleveland district, or in North Lancashire, is quite as wonderful a record of achievement in this respect. But the peculiarity of the shipbuilding industry of the Clyde consists in this, that other rivers were quite as favourably circumstanced, and had quite as much chance of obtaining the same position as the Clyde, and yet the Clyde has left them all a long way behind. The Thames was for many years the mistress of marine architecture. The "wooden walls," which "braved the battle and the breeze" for many generations, and won for England in other days her exceptional prestige as a naval power, were chiefly built on that river. The Thames was far more likely than the Clyde to accomplish all the purposes of marine architecture. The one had skilled workmen; the other had not. The one had a long established and illustrious name and fame, which the other had yet to make. Yet the decadence of the shipbuilding trade of the Thames has been so swift and sure, that it is now admitted to be nowhere in the race; while the Clyde has taken up the premier position after successfully overcoming natural obstacles and difficulties which few other rivers have had to encounter.

The number of steam-vessels built on the Clyde from 1846 to 1852 inclusive was 247. Of these 141 were paddle, and 106 were screw steamers. The wooden hulls numbered 14, and the iron hulls 233. The tonnage of the wooden steamers amounted to 18,331, and of the iron steamers to 129,273. The total value of these vessels and their engines was estimated at £4,331,362, giving an average of £618,766 a year. The progress of the trade continued steady and uninterrupted till 1863, and from that date the development of the trade has been so rapid that the tonnage launched has been almost doubled within ten years. This will be shown from the following table, extracted from the annual statistical report of Mr. West Watson, the City Chamberlain of Glasgow, and compiled, as all that gentleman's reports are known to be, with the utmost regard to accuracy:

SHIPBUILDING ON THE CLYDE, 1863-71.

Year.	Amount of new Tonnage launched during the year.	Amount of new Tonnage on the Stocks or under contract at 31st Dec. of each year.
1863	124,000	140,000
1864	178,505	105,957
1865	153,932	109,404
1866	124,513	71,869
1867	108,024	124,082
1868	169,571	134,818
1869	192,310	140,999
1870	180,401	180,175
1871	196,229	301,809
1872	220,000	

It is interesting to compare these returns with those relating to the shipbuilding launched on the Wear—the next most important centre of the trade in the United Kingdom—for the same period :—

SHIPBUILDING ON THE WEAR, 1863-71.

Year.	No. of Vessels.	Aggregate Tonnage.	Average Tonnage.
1863	171	70,040	410
1864	153	71,987	470
1865	172	73,134	425
1866	145	62,719	432
1867	128	52,249	408
1868	138	70,302	509
1869	122	72,420	585
1870	103	70,084	680
1871	97	81,903	844

At the end of 1871 there were 96,072 tons contracted for or in process of building on the Wear ; 42,122 tons on the Tyne ; and 43,709 tons on the Tees (including Hartlepool) and the Humber, giving an aggregate of 181,903 tons ; so that the tonnage contracted for on the Clyde at the end of 1871 was about 120,000 tons more than that of all the other four principal shipbuilding rivers in England, the Wear, the Tyne, the Tees, and the Humber, put together.

The aggregate tonnage launched on the Clyde within the last ten years represents the enormous amount of 1,667,500, or considerably above a million and a half tons, and if we assess the average cost of the shipbuilding over that period at the low rate of £22 per ton, we have as the educt the colossal sum of nearly £40,000,000 as the value of the vessels built during that period ! There is perhaps no industry in Scotland that is now comparable in point of value and importance with the shipbuilding trade of the Clyde, unless we except the iron and coal industries, which are of course much more widely ramified, and of much older standing.

At the present time there are upwards of thirty separate shipbuilding establishments on the Clyde, between Rutherglen and Greenock, both inclusive. The largest and oldest yards are those nearest to the city, including Messrs. John Elder and Co.'s, Messrs. R. Napier and Son's, Messrs. Barclay, Curle, and Co.'s, Messrs. Tod and Macgregor's, and Messrs. Alexander Stephen and Son's. Of late years, there has been a necessity for the removal of the yards nearest to the Broomielaw, consequent upon the important works for the extension and improvement of the harbour, undertaken by the Clyde Navigation Trustees. As a result of this necessity many new establishments have recently been erected, on a scale of magnitude far surpassing that of the older works, and each rivalling the other in regard to suitability of design, and the most improved principles of construction. The works of Messrs. John Elder and Co. are perhaps the largest and most complete of their kind in the world. The shipbuilding yard, with all its accessories, embraces about seventy acres of land, and gives employment to over five thousand men. This firm has made nearly all the principal vessels for the Pacific Steam Navigation Company. In a single year Messrs. John Elder and Co. have turned out over 30,000 tons of shipping, including vessels for the National Steamship Company, for the British and African Steam Navigation Company, for the Royal Mail Steam Packet Company, for the Compagnie Générale Transatlantique, for the Aberdeen Steam Navigation Company, for the Mediterranean fleet of N. Paquet and Company, for the West Coast of South America Mail Service, for the Pacific Company, and for the Stoomvaart Maatschappy Nederland, or Dutch mail service. The Peninsular and Oriental Company have had most of their vessels built at the works of William Denny and Company, Dumbarton ; and the great Cunard Company contract with Messrs. James and G. Thompson for the construction of nearly all their large ships. It may be said, in short, that there is not a shipping company or firm of any consequence, at home or abroad, that has not got some or all of their vessels built on the Clyde ; so that to give a list of the vessels built on that river for any one year would be to enumerate all the leading shipping companies of the world.

The shipping trade of the Clyde has five principal centres—Glasgow, Greenock, Dumbarton, Port Glasgow, and Renfrew ; but shipbuilding operations on a smaller scale are also carried on at Paisley, Bowling, and Rutherglen. Every one of these towns may be said to be situated upon the Clyde, with the single exception of Paisley ; but as the Cart, upon which the shipbuilding trade of the town is carried on, is a tributary of the Clyde, and as vessels built on the Cart have to be launched on the Clyde, Paisley is naturally ranked among the Clyde shipbuilding ports.

It is very difficult to estimate correctly the number of hands to which the shipbuilding trade of the Clyde gives employment. The number fluctuates from time to time, according as trade is prosperous or otherwise. We base our calculation, however, on tolerably safe and reliable data when we put the total number of operatives directly employed in this industry at not less than 50,000. By those directly employed we mean only the workmen in the shipbuilding yards and in the marine engineering shops, which are now, in the majority of cases, attached to the various yards. Collaterally, of course, the Clyde shipbuilding industry gives employment to a much larger number than this, for the manufacture of marine forgings employs three of the largest works in the west of Scotland—the Parkhead, Lancefield, and Dennystown forges ; while the fabrication of the different materials used in iron shipbuilding, from ship and boiler plates down to nuts, bolts, and screws, will employ a multitude whose number it is impossible to reckon.

There is no more interesting sight to one impressed with the value and the importance of the industrial arts than a voyage down the Clyde. Strangers, as a rule, are totally unprepared for the wonderful display of industrial activity which they witness on all sides in their course between Glasgow and Greenock. Immediately after leaving the Broomielaw, the thud of the ponderous steam-hammer, the clang of the ship and boiler plates under manipulation, the quick and intermittent noise of the riveters, the harsh and grating sound of the sawyers, and many other forms and combinations of the music of labour, strike upon the ear. A little farther down, and the Babel of sound becomes still louder, harsher, and more confusing. In quick succession, the *voyageur* passes on the one side the works of the London and Glasgow Shipbuilding Company, of R. Napier and Sons, of John Elder and Co., and of Alexander Stephen and Sons ; while on the other, and almost directly opposite, there are the works of Barclay, Curle, and Co., Messrs. A. and J. Inglis, Messrs. Tod and Macgregor, Messrs. Thomas Wingate and Co., Messrs. Charles Connel and Co., and Messrs. Aitken and Mansel. After having run the gauntlet of these establishments, there is an interval of green fields and finely-timbered haughs, in passing through which a grateful repose is enjoyed, although it is still possible to hear, fainter and yet more faint, the cadences of the busy scene through which we have just passed. A little farther on, and we reach Renfrew, where Messrs. W. Simons and Co. and Messrs. Henderson and Coulborn carry on large works ; and on the opposite shore we next reach Dumbarton, famous in the days of yore for its wooden argosies, but now rivalling any port on the Clyde with the extensive and well-equipped shipbuilding works of Messrs. Denny Brothers and Messrs. A. M'Millan and Co. From this point the charming beauties of the Clyde begin to unfold themselves, and serve to fascinate the mind, and lead contemplation into other channels, until once again the indulgence of æsthetical taste is diverted by the industrial aspects of Port Glasgow and Greenock, where some of the oldest shipbuilding yards on the Clyde may be seen in active operation. The whole journey is fraught with bewilderment and wonder. Strangers are not always prepared for the fact that the Clyde, which is known far and near as one of the most beautiful of rivers, should at the same time be so distinguished for active and prosperous industry ; and the surprise occasioned by this discovery is most felt by natives of the Clyde ports, who have returned to the place of their birth after an absence of some years, to find a metamorphosis and development which they could scarcely have believed to be possible of accomplishment.

Among recent aspects of the shipbuilding trade of the Clyde, none is more remarkable than the disposition to substitute a larger class of vessels for those at present in use. A few years ago a vessel of over 800 tons burden was accounted a great venture. Take, for example, the "City" or Inman line of Transatlantic steamers, which was originally known, and has elsewhere in this article been referred to, as the Liverpool, New York, and Philadelphia Steamship Company. The "City of Manchester," the "City of Washington," the "City of Baltimore," and the "City of Philadelphia"—the first four vessels especially built for this company—varied from 2,000 to 2,400 tons burden ; and at that time, about seventeen years ago, these were considered marine phenomena in point of size. But, compared with the most recently built vessels for the Inman Company, they are dwarfed into insignificance. Messrs. Tod and Macgregor have lately built for the Inman line the "City of Montreal" and the "City of Richmond," each of which has a gross tonnage of 4,600 tons. Accommodation is provided in each vessel for 100 first-class passengers, 1,200 third-class passengers, and a crew of 100, while the saloon will dine 120 at a time with the utmost ease. All the great Transatlantic companies are following in the same course. The latest vessels built by Messrs. Alex. Stephen and

Sons for the Anchor line are considerably larger than any other ships in the fleet of Messrs. Handyside and Henderson, and the same remark is equally applicable to the new vessels built for the National, the Cunard, and other leading steamship companies. In a long voyage it is an element of essential importance to have as much stowage capacity as possible, and the limits to which the capacity may be safely and advantageously extended are yet so far from being fixed, that we may probably before long see leviathans like the Great Eastern regularly employed in ocean navigation.

We have looked at the progress of the Clyde shipbuilding trade from a scientific and industrial point of view. So far as its purely commercial aspects are concerned, space will not permit of our saying much about them; but this is scarcely necessary, when the facts already stated demonstrate that the history of the trade has been one of rare prosperity. Like every other industry, it has had its vicissitudes and occasional seasons of depression, but it has been oftener on the crest than in the trough, and its immediate prospects give no cause for despondency. In spite of the extraordinary advance in the cost of shipbuilding materials which the last two years have witnessed, and notwithstanding the shorter hours and larger wages conceded to all classes of operatives, shipbuilders are entitled to take heart of grace, for the requirements of civilization and commerce will not be satisfied until the nations of the earth are linked together by closer and more permanent ties than those now in operation. Shipping and shipbuilding, hand in hand, will be a principal means in the accomplishment of this beneficent end.

Mr. Robert Napier.

No man has been more conspicuously associated with the development of marine architecture than Mr. Robert Napier. His name will ever rank among the pioneers of that industry. There have been as great (perhaps there have been even greater) naval architects, so far as mere knowledge and skill are concerned. It would, perhaps, be too much to claim for Mr. Napier the profound and incisive acquaintance with theoretical formulæ that distinguished the late Professor Rankine, or the equally exhaustive practical familiarity with the art of ship-building that have made the names of Mr. Reed, the late Chief Constructor of the Navy, and Mr. Laird, of Birkenhead, "familiar in our mouths as household words." But while we would not maintain that in their special and peculiar walks Mr. Napier excelled these men, we do not hesitate to ascribe to that gentleman a combination of theoretical and practical knowledge allied to an organizing and administrative capacity that cannot be claimed for any other living man. So far as the Clyde is more particularly concerned, marine architecture owes more to Mr. Napier than to any one else. He did much to bring that art to the high degree of perfectibility it has now attained; but, what is of not less importance in its bearing on the history of the trade, he assisted in projecting those "enterprises of great pith and moment" without which it would have been impossible for the Clyde to have attained its pre-eminence in relation to the industry with which his name is so intimately associated.

Robert Napier's early training was calculated in a special degree to qualify him for his subsequent career. His father was a blacksmith at Dumbarton, about twelve miles from Glasgow; and it was here, on the 18th day of June, 1791, that Robert was born. The son was early trained to the business of the sire, so that, as the former has pithily remarked, he was born with the hammer in his hand. Like many working-men in Scotland who have not themselves had the benefit of a good education, the elder Napier was anxious to confer that advantage upon his son. Robert had, therefore, a fair schooling, which was improved upon as he grew older by attendance at evening classes and lectures in his native town. With his father he served the regular apprenticeship of a blacksmith, and when he had reached his twentieth year he left Dumbarton with the view of seeking employment in Edinburgh. He was successful, after some search, in finding an engagement under Stephenson, the eminent lighthouse engineer, for whom he worked for some two or three years, and from whom he learned not a few details of his business that the limited operations of his father did not enable him to acquire.

A blacksmith does not require a large capital. A forge, an anvil, and a few tools form the bulk of his stock-in-trade; and these can easily be got together. Robert Napier, in his twenty-fourth year, began to have serious thoughts of establishing himself in a business of his own. With a capital of £30, obtained from his own savings as a journeyman, he started business in Glasgow in the month of May, 1815. His first workshop was in Greyfriars Wynd. It was a wretched little place compared with the larger and more pretentious workshops of the present day; but on account of its historical interest, it was preserved intact until about two years ago, when the operations of the Glasgow City Improvement Trustees necessitated its removal.

Hard and incessant toil at the anvil, laborious days and few delights, were the means by which Napier qualified himself for the position he was destined to take up. With the aid of only two apprentices he was able to overtake all the work that came to hand for the first two or three years. But his aspirations were superior to the shoeing of horses and other drudgery of the blacksmith's shop, and he steadily and industriously persevered until he was able to extend his connection so far as to undertake general engineering work. For this purpose he removed from Greyfriars Wynd to Camlachie Foundry, where he carried out several contracts of considerable importance. One of these contracts was for the supply of the pipes required by the Glasgow Water Company, when bringing the water supply from the upper reaches of the Clyde. A little time longer, and he was enabled to undertake the construction of both land and marine engines. His first land engine, a quaint but substantial piece of mechanism, is still, or was lately, in use in a spinning factory in Dundee.

His contract for the construction of the engines for the "Leven," a small paddle steamer that plied for many years between Glasgow and Dumbarton, may be regarded as a landmark in Mr. Napier's career. Steamers were about this time coming into general use, especially for lake and river navigation; and it required no great penetration to discern that in course of time steamships would take the place of vessels sail-impelled. It is easy to understand that this consideration occurred to Mr. Napier's mind, and induced him to pay special attention to that department of engineering wherein he was to make an enduring mark. But it required close and careful calculation to enable him to take up the position to which he aspired. There were older and better known competitors in the field. Mr. Napier had no one to take him by the hand. He was yet a young, unknown, and untried man; and he had not only to fight against these difficulties, but also against his lack of special technical training for the new branch of trade upon which he had now entered.

The owners of the "Leven" were so well pleased with the manner in which Mr. Napier had engined that vessel, that they recommended him for other work. In 1826, he engined the "Eclipse," one of the first vessels employed on the Glasgow and Belfast route; and the engines of several other vessels built for the coasting trade were entrusted to his construction.

About 1830 Mr. Napier became connected pecuniarily with the City of Glasgow Steam Packet Company (projected for the purpose of running first-class vessels between the ports of Glasgow and Liverpool) under rather interesting circumstances. The trade between Liverpool and the Clyde had been carried on for many years by sailing vessels, which were improved from time to time until they reached the model, which, under the name of the London and Leith smack, became so noted for speed and safety. In those days the voyage between Liverpool and Greenock occupied between three and four days. In 1819, however, the "Robert Bruce" and the "United Kingdom," the first vessels placed on the line, began to ply regularly between the Mersey and the Clyde; and in 1823, the Glasgow and Liverpool Steamship Company was projected for the purpose of running their new and specially-built steamers the "Superb," the "Rob Roy," the "Majestic," and the "City of Glasgow" between Liverpool and Greenock, carrying cargo, passengers, and mails between these ports, and also leaving and taking up mails at Ramsey in the Isle of Man. This company was afterwards merged in another, for which the steamer "Henry Bell," "James Watt," and "William Huskisson," each of 100-horse power, were constructed. This line of steamers ultimately fell into the hands of the Messrs. Burns of Glasgow, the late Mr. David M'Iver, of Liverpool, Mr. Archibald M'Connel, and Mr. Robert Napier, who purchased the interests of the existing rival companies, which they amalgamated with their own, naming the now combined establishment the City of Glasgow Steam Packet Company. The career of the new line was marked by great prosperity, but is particularly notable on account of its having been the forerunner and basis of the great Cunard line, of which more hereafter.

His connection with an enterprise so important and successful as the City of Glasgow Steam Packet Company was the means of procuring for Mr. Napier introductions to many gentlemen interested in the shipping trade, and thus assisted him to take up a more conspicuous position as a marine engineer. In the year 1834 he contracted for and engined several vessels for the Dundee and London Steam Shipping Company, of which his late friend Mr. George Duncan, M.P. for Dundee, was a leading director. It was remarked of these vessels that they were much superior, in point of finish, equipment, and general appearance, to any other vessels that frequented the London Docks at that time.

The next most important event in Mr. Napier's career, if not *the* most important event of his whole life, was his association with Sir Samuel Cunard and other gentlemen in the formation of the British and North American Mail Company, now better known as the Cunard line. In the year 1840, Sir Samuel Cunard visited London for the purpose of organizing a line of steamships between that city and New York. He was introduced by Sir James Melvill, of the India House, to Mr. Napier. Sir Samuel's original idea was to build four vessels, each 900 tons burden and 300-horse power; but Mr. Napier pointed out that vessels of this small size would be inadequate for the requirements of the Atlantic trade, and suggested that they should at least be 1,200 tons burden and 400-horse power. They could not, however, see eye to eye in this matter, and Mr. Napier had actually proceeded with the construction of the vessels according to Sir Samuel's original plan, when the latter, on second thoughts, endorsed Mr. Napier's views as to what such vessels should be, although he added that to build them such a large size would involve a greater loss than he, as a private individual, was prepared to undertake. This did not appear to Mr. Napier to be any insurmountable obstacle in the way of the undertaking. He canvassed several of his friends on the subject, and ultimately about twenty gentlemen, of whom Mr. Napier, Mr. George Burns of Glasgow, Mr. M'Iver of Liverpool, and Sir James Campbell of Glasgow, are the only survivors, formed themselves into a company for the purpose of carrying out Sir Samuel's views. This was the origin of the now world-famous Cunard Company. The construction of the first four vessels of the line was entrusted to Mr. Napier, who contracted with Mr. Robert Duncan, Mr. John Wood, Mr. Charles Wood, and Mr. Steele, all Clyde shipbuilders, for the supply of the hulls; while he himself furnished the engines. The names of the pioneer steamers were the "Britannia," the "Arcadia," the "Caledonia," and the "Columbia." They were respectively of 1,154, 1,135, 1,138, and 1,175 tons, and each was furnished with engines of 440-horse power. From an article in the "Liverpool Journal of Commerce," we learn that the "Britannia," under the command of Lieut. Woodruff, of the Royal Navy, sailed from Liverpool on the 4th of July, 1840, and reached Boston in 14 days 8 hours, taking one month's later news from Europe than had been received by the immediately previous arrival. "An immense amount of interest was concentrated on this voyage, both in this country and in America. At Boston her arrival was watched for with great anxiety, and although it was late on a Saturday evening when she entered the harbour, the wharves were crowded with people, and salutes of cannon were fired in honour of the event, from which the most enthusiastic anticipations of national advantage were formed. The popular enthusiasm indeed appeared to have run wild, and it exhibited itself in a variety of ways. A grand banquet was given on the 22nd of July, three days after her arrival, in celebration of the establishment of steam postal communication between Great Britain and America. This banquet was presided over by Mr. Josiah Quincey, jun., and complimentary speeches were made on the occasion by several of the most eminent statesmen of the period. As another evidence of the general appreciation with which the establishment of this line of communication was hailed by the general public as well as by the Government of America, it may be deemed not altogether uninteresting to state that Sir Samuel (then Mr.) Cunard, who arrived 'in the 'Britannia,' received no fewer than 1,800 invitations to dinners, in 24 hours. That the expectation formed by the citizens of Boston as to the benefits they should derive from this new and regular means of communication were not greatly exaggerated, may be in some degree inferred from the fact that, under the powerful stimulus of steam travelling by sea and by land, the foreign imports at Boston increased from $14,000,000 in 1840, to $38,000,000 in 1850, and in 1857 they had reached $48,500,000, having thus increased nearly fourfold in less than twenty years."

For some years Mr. Napier continued to supply all the vessels required by the Cunard Company, including the "Hibernia," the "America," the "Niagara," the "Europa," the "Canada," and the "Arabia." In 1856 he built the "Persia," of 3,300 tons and 900-horse power, and in 1862 the "Scotia," of 3,870 tons and 1,000-horse power. These latter were the first paddle-steamers built for the Cunard Company, all the first fourteen vessels built for this line having been made of wood. It is noteworthy that the "Scotia," in the autumn of 1863, made the voyage from Liverpool to New York in ten days and two and a quarter hours, including a stoppage of ten hours at Queenstown; and in December of the same year she made the run from New York to Liverpool in the unprecedentedly short period of nine days and nine and three-quarter hours, detention at Queenstown included, and deducting difference of time—four hours forty-five minutes—between New York and Liverpool time, in eight days and twenty-two hours. The only approach to this feat in ocean steam-navigation, up to 1865, was made by the Cunard Company's steamer "Persia," although within the last few years, the "City of Paris," belonging to the Inman line, beat the Cunard liner, "Russia," in an Atlantic race, by about twenty minutes, performing the shortest voyage that had then been attained; and more recently, the "City of Brussels" made the voyage between Liverpool and New York in eight days, and earned for herself the honour of being the fastest Transatlantic liner afloat.

It is now conceded on all hands that the Cunard steam fleet is the finest in the world, and the operations of the company have been successful beyond all precedent. The company possess, at the present time, between forty and fifty vessels, afloat or in course of construction. Some of these ships are over 4,000 tons burden, and the aggregate tonnage of the whole is about 90,000 tons! Some idea of the capital sunk in this magnificent fleet may be gathered from the fact, that the average cost of the construction and equipment of a Cunard liner is about £100,000! The exemption from misadventure enjoyed by the company is not only beyond all precedent, but it is also among the greatest phenomena of the shipping trade. For upwards of thirty years a Cunard liner has sailed from Liverpool to New York—at first once a week, then twice a week, and more recently three times a week—while the same number have been run from New York or Boston. But the Cunard captains appear to have mastered the domain of old Neptune, for during all that long period they have never lost either a life or a letter!

There are other interesting phases of Mr. Napier's career that ought not to be passed over cursorily; but space demands brevity at the hands of the writer. Briefly, then, we may further say, that he supplied some of the first steamers built for the East India Company, including the "Berenice," of 220-horse power, in the year 1836, and the "Zenobia," of 280-horse power, some time afterwards. Both of these vessels were used by the company as war and packet ships. In 1839 he built for the same owners the "British Queen," of 420-horse power, which was then considered the largest and most powerful steamer afloat.

In 1840 the British Government contracted with Mr. Napier to supply engines for two new war-vessels, the "Vesuvius" and the "Stromboli," and in 1843, when a return of the cost and repairs, &c., of a number of war-ships was ordered by the House of Commons, it was stated that the work executed by Mr. Napier stood the test most favourably compared with that executed by other engineers.

When it was decided to reconstruct the British navy with armour-clad vessels, Mr. Napier had the honour of a commission to build the "Black Prince," of 6,040 tons and 800-horse power, one of the first two armour-clad ships constructed in this country. He also supplied to the order of the British Government the "Audacious" and the "Invincible," two armour-clad frigates, each 3,775 tons and 800-horse power. Within the last two or three years Mr. Napier's firm has supplied Her Majesty's Government with the "Hotspur," another war ship, and the "Kite" and the "Bustard," two gunboats intended for service abroad.

In the earlier days of steam navigation, and before it had been applied to Government vessels, the Admiralty were without any school or dockyard for the instruction of naval officers. Admission to the private shipbuilding establishments on the Thames, such as Mosley's and Rennie's, was refused them; but Mr. Napier gave them *carte blanche* as to the use of his works on the Clyde, and thereby strengthened his own influence with the Admiralty.

It is not the least interesting feature of Mr. Napier's life that some of the most eminent shipbuilders and marine engineers of the day were indebted to him for their early training. Of this number we need only mention the late Mr. John Elder, who became one of Mr. Napier's managers, and in that capacity displayed not a little of the engineering genius which subsequently raised him to the highest place in his profession, and made him head of one of the largest private shipbuilding establishments in the world.

Many honours have been bestowed upon Mr. Napier in consideration of his eminent services to naval architecture. In 1869 he was created a Commander of the Most Ancient Order of the Dannebrog, first-class, by the King of Denmark. At the Paris Exhibition of 1855 he was made a Chevalier of the Legion of Honour, and was awarded the great gold medal of honour, in acknowledgment of the success that had attended his labours on behalf of steam navigation. He was appointed a juror of the Paris Exhibition (1855); chairman of the jury for class 12 (Naval Architecture, &c.) of the National Exhibition of 1862, and a Royal Commissioner of the Paris Exhibition of 1867, when he received a grand prize. He was also elected one of the Committee for the Organization of the Fine Art Exhibition held in the South Kensington Museum in connection with the International Exhibition of 1862. By the engineering world he

will long be remembered as President of the Glasgow Meeting of the Institution of Mechanical Engineers in 1864, when he displayed a princely hospitality, and when the members of the Institution were allowed an opportunity of inspecting his splendid, if not unique, collection of old china, pictures, and other articles of *vertu*. Retired from the actual management of the business which he has made so famous, Mr. Napier has resided for many years past at his palatial residence on the banks of the Gareloch; and although over eighty years of age, we may truly say that "his eye is not dim nor his natural force abated." He is still in the full enjoyment of all his faculties, and uses them ungrudgingly for the entertainment of the many visitors to his magnificent abode. JAS. S. JEANS.

THE FIVE FIRES OF THE PARIS OPERA HOUSE.

1763, 1781, 1788, 1871, 1873.

THE recent total destruction of the well-known building in the Rue Lepelletier has served once again to direct serious attention to the frightful risks at present attaching to theatres; and when it is remembered that notwithstanding all the precautions invariably taken this is the fifth occasion on which the National Opera of France has been left without a home, it seems imperatively necessary for those interested in the subject to investigate the circumstances under which these terrible losses have occurred.

In an article on theatres which will be found in the preceding volume of this magazine (volume ii. p. 84), it was asserted that, without interfering with any of the legitimate objects for which such places are constructed and maintained, it is possible to insure the absolute safety of audiences and the partial safety of the buildings and contents in case of fire, and this opinion is here repeated and most strongly insisted on. Indeed, it must be obvious to every one considering the subject from a practical point of view, first that it is advisable to divide theatres into several different risks, and secondly, that it is possible to do so; and the object of the present article is to present a summary of several heavy losses caused by neglect of the principles there laid down—a neglect, moreover, persisted in by those responsible, and repeated over and over again, as the following narratives will show.

The buildings of the Paris Opera have been on fire no less than five times within the last 110 years, namely in 1763, 1781, 1788, 1871, and 1873 respectively, and a short account of each of these fires, taken from authentic French sources, may serve to convey instruction to those willing to learn.

THE FIRE OF 1763.

Between 11 o'clock and mid-day on the 6th of April, 1763, a column of smoke, dense and black, rose above the right wing of the Palais-Royal. Fire had suddenly broken out in the Opera.

The following account is taken from the *procès-verbal* drawn up in the office of the Hôtel de Ville immediately after the disaster:—

"On the 6th of April, 1763, about mid-day, intelligence reached the Hôtel de Ville that fire was raging with the greatest violence in the Opera House, and the officials of the bureau at once repaired to the spot; but the damage was already beyond the reach of help, and, notwithstanding every possible exertion, everything was devoured by the flames in a very short time, and the building and its contents utterly destroyed from top to bottom. They nevertheless prevented the fire gaining ground in the direction of the houses looking on the Rue Saint-Honoré; but the fire attacked the Palais-Royal with so much violence that the buildings of the Cour de Cadran and the Cour des Fontaines were very much damaged.

"The old buildings abutting on the grand staircase of the theatre were entirely consumed, or very nearly so.

"It cannot be absolutely stated in what way the fire commenced, because it was the day following Easter-day, on which day there was no performance, but it so happened that they were going to make some repairs or to have a rehearsal.

"The King has charged the town to construct a provisional Opera House at the Théâtre des Machines at the Palace of the Tuileries. His Majesty, at the representation of Monseigneur the Duke of Orleans, has commanded the town to reconstruct a new Opera House according to designs which shall be approved for the purpose by his said Majesty, using the ground space which will be given to him by the Duke of Orleans, who has undertaken to pay for the acquisition of the necessary houses.

"As the King ordered the actors, actresses, and *employés* of the Opera not to leave Paris, but to attend to their ordinary work, a French concert (*concert français*) has been established in the concert-room of the Tuileries, and, out of the total receipts realized, the town has made the directors of the Opera pay for the appointments of the actors, actresses, and *employés*, as well as the expenses of the said concerts.

"The plan for the new Opera House has been made by M. Moreau, who has been entrusted with the exercise and functions of the office of master-general of the town buildings, and it has been approved by the king on the day indicated, in presence of Monseigneur the Duke of Orleans, M. le Comte de Saint-Florentin, Secretary of State for Paris, and M. le Prévost des Marchands."—*National Archives, Register of the City of Paris*, 1762-3.

This is the *procès-verbal* in all its dryness. The writer of the document does not venture to enter into an explanation of the causes of the fire. Collé, in his "Journal Historique," does not declare for any of the versions current in his time. The "Gazette de France" and "Le Mercure," two leading periodicals of the time, are not much more communicative. The pages of the national records contain very few manuscript pieces under the administration of the Royal Academy of Music during the year 1763; but the "Mémoires secrets de Bachaumont" abandon this reserve, and say that the fire began at about eight o'clock in the morning, through the fault of the workmen employed in the interior, and that it increased by their neglecting to call help and attempting to conceal it; and they add that, by a singular infringement of the regulations, the porters had deserted their lodge. Castil-Blaze has seized upon these statements, and in his history of the Academy of Music, has worked out of them a fantastical story, in which he allows his southern imagination full career. According to him the fire came from a little room near the apartments of M. de Montausier, Governor of the Palais-Royal.

"There was a stove, the funnel of which entered the chimney of the ballet-girls' dressing-rooms. They had forced the heat in this stove, and when it was quite choked the funnel split, and set fire to the chimney. Then the flame escaping caught some woodwork, which lighted up instantly like a match. It occurred during the closing for Easter; there was not a workman in the building, not as much as one of the call-boys, and even the *concierge* had gone out. A single singer, preparing himself for his *début*, came on the stage early in the morning to try his voice, observed the fire, and rushed out crying for help; but before help arrived all was lost." This is Castil-Blaze's story; but as to its truth or error no opinion is offered.

Another account is that of a machinist named Boullet, who was an eye-witness of the fires both in 1763 and 1781, and was probably actively engaged in extinguishing them, as it appears that he was wounded twice. This man said that a sweeper, who was employed in the morning, left his work and went out, after having placed his candle on the counterweight of the drop-scene curtain. The light set fire to the ropes of the counterweight; the curtain, deprived of its balance, came down, and the ropes serving as a vehicle for the flame, mounted to the friezes, which in their turn became enveloped.

At mid-day the fire was master of its prey, and defied all human intervention, threatening on one side the Palais-Royal by the wing of the building adjoining the Opera House, and on the other side the Rue Saint-Honoré, by the houses of the *cul-de-sac* of the Opera. In the garden of the Palace two immense chains were formed—chains of coarse cloth and of silk—composed of persons of every rank, without distinction of dignity, age, or even sex. One sought to save the archives and the celebrated pictures of the Galerie; the other supplied water for the fire-engines, which worked without cessation. About two thousand persons were employed in this way. In the middle of the courts and passages were heaped up piles of furniture and property, under the guns of the Duke of Orleans, and guarded by his servants.

At about half-past one o'clock the cupola of the grand staircase of the Palace came down, and then a frightful noise was heard: it was the dome of the Opera House falling in, and with it some of the adjoining roofs, which thus poured down their *débris* incessantly, and added fuel to the fire.

After this the fire still raged with great violence, and it was not until six o'clock in the evening that the quarter surrounding the Palais-Royal was out of danger.

There are many other particulars of interest connected with this fire; but the principal points for consideration here are, first, the fact that the building was beyond the reach of help immediately after the fire was discovered, and was totally destroyed within an hour and a-half of that time; secondly, the almost absolute certainty that if the building, instead of being all in one

risk, had been divided into several, this great catastrophe would have been averted.

After this fire a great many projects were started for the site and construction of a new Opera House. Some wanted to have it at the Caroussel, and others at the Louvre; but a proposal of the Duke of Orleans was adopted. The duke repaired to Versailles, and asked the king to allow the Opera to remain at the Palais-Royal, offering the site, and a hundred thousand crowns towards the expenses. The king decided in favour of the duke, and during the reconstruction the Opera found a commodious home at the Tuileries, in the part known as the "Salle des Machines," where the "Concerts Français" were opened on the 29th of April by the artists of the Academy of Music.

The Fire of 1781.

The new Opera House, which was commenced in 1764, and publicly inaugurated on the 26th of January, 1770, was constructed at the expense of the city, from the drawings of M. Moreau of the Academy of Architecture, on the land furnished by the Duke of Orleans.

Several works state that it was situated in the Cour des Fontaines; but this is hardly a correct description, as no egress or entrance, either of the chorus, the corps de ballet, or the supernumeraries, was possible on that side.

It occupied about the space included between the Rue de Valois and the Rue des Bons-Enfants, with a façade on the Rue Saint-Honoré. The *cul-de-sac* of the Opera, as also the block of houses formerly extending along the Rue des Bons-Enfants, had disappeared, absorbed in the plan of the building. The Rue de Valois is the approximate axis round which the two salles of the Palais-Royal were turned, from left to right. This is not very clear, but it is difficult to define the site more accurately for those only acquainted with the Paris of 1873.

The interior arrangement of M. Moreau's house was thus described in the programme :—

"*Second Theatre of the Palais Royal.*

"The opening of the stage is 36 ft. wide and 32 ft. high. This advantageous arrangement brings all the nearer the end of the auditorium (*avant scène*) and causes more equality in the different situations of the spectators. Its form is round, giving at the top a beautiful oval, filled by an allegorical painting, of which mention is made elsewhere, in order not to distract the eyes of the reader from the object here presented.

"The auditorium is decorated by four columns of a rich and elegant order, the flutings of which are open, so that this part, generally consecrated alone to decoration, furnishes the most commodious and best places. Their shaft is divided by drums at the height of the ledge of the boxes contrived in their intervals, which is perhaps prejudicial to the elegance of the Corinthian order; but, on the other hand, makes more prominent these same boxes, which the architect would doubtless not have done, and still less those formed in their socles or plinths, had he not been obliged to reconcile pecuniary interests with artistic decoration."

The building was made to contain 2,500 spectators, all said to be nearly equally well placed, and the description goes on :— "The convenience of the public has not been forgotten, as shown by the exits. Safety is one of the points to which the most scrupulous attention has been directed; three reservoirs, containing together about 200 hogsheads of water, are placed in situations where they will be the most useful in case of fire. The actors' dressing-rooms are all constructed of brick, and vaulted, and most of the stairs are of stone."

The result of the arrangements here so confidently described appears further on.

On Friday, the 8th of June, 1781, the programme of the opera was composed of "Orphée," words by M. Moline, music by M. le Chevalier Gluck, preceded by the act of "Apollon et Coronis," set to music by the Messrs. Rey, the one music-master of the king's chamber, the other musician in ordinary of his Majesty's chapel.

Ten minutes had hardly elapsed since the end of the performance. It was half-past eight o'clock in the evening; the opera at that time began at five o'clock, and the public had left. The people who had danced in the last ballet were quietly undressing in their rooms, when on a sudden cries of anguish resounded on the scene. "Fire! fire!" For the second time in eighteen years fire was going to devour the Opera.

What was the origin of it? Perhaps it was never rightly known. "It is presumed," says Bachaumont, "that it may have been originated during the third act of 'Orphée,' representing the fire of hell, the flakes of which, flying to the roof, produced there a smouldering fire, which at the end of a certain time burst out and burnt up everything." According to other accounts, a candle of a side frame might have communicated its flame to the curtains. What is certain is, that the fire caught a sort of gauze made to represent the sky.

At first a glass of water would have sufficed to extinguish it; but by an unheard of negligence, there was not a drop of water in the reservoir of the theatre. A cry was raised to cut the ropes of the gauze, and one of the workmen, a machinist, succeeded in doing this at one side, but at one side only; the gauze inclined, crossed the stage diagonally, and fell against the canvas at the upper end. This movement redoubled the activity of the flame, which invaded the stage and the whole building with the rapidity of lightning.

An immense furnace had become alight. Towards half-past nine o'clock the timber-work of the edifice gave way, opening out a passage to a column of fire more than 300 ft. in height. Horrible gleams illuminated all the neighbourhood; in the distance, in the cross-ways, and on the public squares, the assembled people, with their eyes fixed on that spout of flame which lost itself in the azure of heaven, thought there was a fall of stars from the height of the firmament. For two hours this fantastic serpent rose into the air; myriads of fire-flakes, burning charcoal, and innumerable sparks detached themselves from the mass, and went away carried by a light wind, to fall in the Rue Saint-Martin and in the Faubourg Montmartre. Happily rain came on; but without this unexpected aid, Paris, like London, might perhaps have had her historical fire.

The lesson to be learned from this catastrophe is, that the whole place was quickly alight, which would not have been the case if it had not been all in one risk.

On the roofs of the Royal Library and the buildings of the Douane there were workmen on watch. Help was directed by the Prévôt des Marchands, the lieutenant of police, the commissaires of eleven quartiers, and the Duc de Chartres in person. Under their orders the Gardes Françoises and the Gardes Suisses, the Garde de Paris, the récollets, monks of the order of St. Francis, capucins cordeliers, and Franciscan friars of 1763, did their duty bravely. A letter inserted in the "Journal de Paris" of the 13th of June, pays in the name of all the inhabitants of Paris a just tribute of praise also to the corps of firemen commanded by Morat. "I venture to assert," says the author of the letter, "that there is no extensive fire which does not give rise to some heroic action on their part; but history does not engrave their names in its annals." The "Gazette" and the newspapers do not celebrate their actions, and they only become on that account the more worthy of our homage, since the courage, which leads them every day to brave death, never has either of the two most powerful incentives which lead men to do right, glory and fortune. In this last fire, which spread consternation over the capital, what courage, what intelligence, what indefatigable activity was needed to circumscribe the conflagration in its first central point, and to prevent it from spreading beyond! Thanks to them, the Palais-Royal was preserved; there were only damaged the chambers contiguous to the Opera on the side of the Cour des Fontaines. Of the buildings of the Opera, there only remained the boxes of the principal actors by the green-room, and the treasury. The large saloon underwent the full force of the flames, but it was not entirely destroyed. The bust of Rameau in the grand staircase was broken, those of Lulli and Gluck escaped the fate of their companion.

In the midst of this frightful tumult the men and women dancers, who were half undressed in their rooms at the outbreak, and the workmen employed about the stage and wings, overcome with panic and blinded by smoke, were unable to find the outer doors, and perished in the raging furnace.

On the 10th of June, eleven dead bodies half burned away were found under the ruins, and an old woman who lived in the Cour des Fontaines died of fright the same day. These twelve are probably all that were known with any certainty to have lost their lives; but on the 20th of June, when the last of the *débris* was being cleared away, some other bones were found, though the reports preserved in the archives do not make mention of this fact. During the first days people greatly exaggerated the number of the victims, counting as dead all the *employés* and *artistes* of the theatre whom wounds or prudence kept at home; but after several appeals made by the administrator, it was generally acknowledged, that beyond the unfortunate people already mentioned, whose bodies had been found on the 10th, there were probably no other losses of life among the *personnel* of the Opera. Gardel le Cadet, as to whose fate some fear had been experienced, soon appeared again safe and sound, quite disposed for the *sarabande* and the *chaconne*. An ill-timed and unseasonable fit of modesty imperilled the life of la Guimard. Almost without clothes in the room where she changed her toilet, she did not dare to leave, and was on the point of being suffocated, when a machinist had sufficient presence of mind to roll her up in the curtains and carry her out. Beaupré killed himself, jumping

from the third floor. Castil-Blaze made a dramatic episode out of the death of little Vidal. "Huart, a vigorous dancer, and a tall man, having only two floors to jump, made towards the roof of a shop, slid into the Cour des Fontaines, and fell on his feet without hurting himself. His valet, a boy of fifteen, was at the window, and did not dare to throw himself out of it. Huart stretched his arms to him, called him, encouraged him, saying that he was ready to receive him, and to ward off the blow from him. Nothing could decide this unfortunate boy, not even the fire which soon reached him, and burnt him alive under the eyes of his master."

The case is affecting; but the weak point of Castil-Blaze's story is that M. Huart was very grievously wounded by his own fall, and not in a condition to undertake the athletic feat attributed to him.

After the following story of the violinist Châlon there may be no difficulty in believing that the Garonne was flowing through Paris in the time of Castil-Blaze.

"Châlon, a violinist, remained behind a few steps, and the wing of a slamming door shut in front of him. He made vain efforts to open it, but the pressure of air glued and fixed the wing to its frame. Happily the door joined badly at the bottom, and the musician stripped off all his clothes, and, lying down on his face and hands, compressed himself like a cat or a lizard, passed as from a flatting mill, and managed to squeeze himself under the door, leaving on it the skin of the muscles of his back; and several powerful machinists pulled him from the other side. Châlon recovered from it, but for the rest of his life he could not make the slightest bow; stiff as an Egyptian statue, he saluted with his hand." In this case it is difficult to judge whether the man or the story was the more elastic.

Most of the dancers took flight by the tops of the neighbouring houses, jumping from gutter to gutter, and precipitating themselves into the street at the risk of breaking their necks.

Some of the dancers were able to find the passages of outlet on the Rue Saint-Honoré, and fled in their chemises by the Place du Palais-Royal. No one laughed much at the time, but shortly afterwards they did not restrain themselves. The *beaux esprits* of the Terrace des Feuillants repeated among themselves numbers of anecdotes and jokes, and amongst the rest the following playful letter, attributed to Sophie Arnould, in which she made allusion to the misadventure of these poor women:—

"Paris, 26th June, 1781.

"This frightful fire has left the divinities of the Opera almost naked. The fire communicated to the rooms in which their clothes were kept, and it was only by a miracle that they managed to save some.

"Venus's girdle is consumed; the Graces will go without veils; Mercury's cap, his wings, and his caduceus, are no more; for a long time Love has had nothing to lose at the Opera, and so has lost nothing; but the shield of Pallas and the lyre of Apollo are in ashes.

"The chariot of the Sun and of Nature, which hung so gracefully in the air in the very natural prologue of 'Tarare,' has not been spared any more than the folds of gauze which draped very palpable shadows. I should never finish, dear friend, if I were to tell you everything we have lost.

"But money can repair all such losses."

The Parisians, however, had not waited for Sophie Arnould's letter to amuse themselves on the subject of the fire.

On the very next day after the event, the crowds remained stationary on the Place du Palais-Royal, contemplating sorrowfully the ruins heaped up under their eyes. A cart laden with costumes saved from the flames was crossing the Place; a porter thought of putting on a plumed helmet which he found at hand; then, throwing over his shoulders a purple cloak, he stood upright in the cart, proudly draped in these tinsels, with the superb countenance of a Roman emperor ascending to the Capitol. The sadness of the spectators changed as if by magic into loud shouts of laughter, and the porter was enthusiastically applauded.

The ruins of the Opera were still smoking when it became the great fashion in Paris to wear a stuff known as *couleur feu*, or *fumée d'Opéra*.

The following is a list of the decorations burnt in the fire of 1781, taken from the official report deposited in the national archives. This report is divided into three sections, comprising the inventory, firstly, of thirty-three decorations, all to be repainted, but able to be utilized for the Salle des Tuileries, where it was already decided to move the Opera; secondly, of burnt decorations; thirdly, of forty-eight decorations which were intact, but not fit to be used for the Tuileries on account of their dimensions.

Burnt Decorations.

Palace of Ninus, used in the "Iphigénie" of M. Gluck.
Palace of Aménophis in the "Iphigénie" of M. Piccini.
The end of the palace of Zélindor, in "Le Bon Seigneur."
Hamlet of the Devin du Village, in "Coronis."
The entrance into hell, in "Orphée."
The enchanted island of Thésée, in "Orphée."
Temple of Amphion, in the "Iphigénie" of M. Piccini.
Temple of Jupiter, in "Hercule mourant."
Public square of Alceste.
Mountain of Sylvie.
The twelve heavens.
The curtain of the drop-scene.
Portico of the palace of Agamemnon.
The forecourt of the palace of Admète, in "Andromaque."
The burning palace used in the "Bon Seigneur."
Hamlet of the "Bon Seigneur."
Desert and labyrinth in "Orphée."
Temple of Maspha, in the "Iphigénie" of Gluck.
Subterranean temple of Arimane, in the "Iphigénie" of M. Piccini.
Temple of Love, in "Orphée."
The Elysian fields, in "Orphée."
The farm in the "Iphigénie in Aulide."
The decorations of the ball-room generally.
The tomb of Euridice.

To this extract from the losses of the State, must be added the losses of all kinds caused to individuals. The inhabitants of the Palais-Royal and the adjacent streets missed or lost in their nocturnal removal a number of articles, clothes and furniture, which the "Affiches de Paris" of the month of June reclaimed by hue and cry. As to Sophie Arnould, so fertile in jests on the dancers of the Opera, she did not feel safe in the quartier of the Palais-Royal, and removed at once from the Rue des Petits-Champs, where she occupied an apartment, to the Rue Caumartin, which was better situated for exercising her wit at liberty.

The fire of the Opera, the support of so many families, dealt a terrible blow to all concerned in it. The director himself, Dauvergne, a respectable man of seventy years of age, and encumbered with numerous children, was obliged to ask for an extraordinary gratuity to assist towards the needs of his housekeeping, and many others were for a long time dependent on charity.

The concerts at the Tuileries were not attended with such *empressement* as to promise large receipts, and the administration decided on the transfer of the Opera to the Salle des Menus-Plaisirs, where the royal troupe inaugurated its performances on the 14th of August, 1781, by "le Devin du Village," followed by "Myrtil et Lycoris."

An order had been given to Dauvergne not to grant leave to any member of the Academy, and the order was rigorously executed; Noverras and Mademoiselle Ollivier alone obtained a pass from the minister to go, the one to Bordeaux, the other to Brussels.

M. Adolphe Jullien has lately published in the "Revue de France" a very curious article on a plot contrived between Rousseau, Lays, and Chéron to escape to Brussels without leave. These gentlemen looked upon it as unworthy of their talent to play at the little "Salle des Menus," and estimated that the contents would be more valuable than the building. Lays was stopped at the diligence; Chéron kept himself quiet; but Rousseau, notwithstanding the exchange of diplomatic notes between Belgium and France, gained the frontier, baffled the police, and succeeded in reaching Brussels.

The projects concerning the construction of an Opera House continued to go on. The sites proposed were the "Salle des Elèves de l'Opéra" on the Boulevard, the "Colisée, the "Vieux Louvre," the "Carrousel," the fair of "Saint-Germain," the "Jardin de l'Infante," the grounds of the "Filles-Dieu," and others. Every Parisian had his Opera House in his head. "It appears," wrote M. de la Ferté to the minister on the 20th of July, "that the public desires the Opera so ardently, that yesterday at the Redoute-Chinoise they were heard to declare openly that if even the Opera should be placed at Pantin or at the Antipodes, they would go to hear it, which shows at least a great enthusiasm for this spectacle."

At last, the architect Lenoir, whose plan had been chosen, was entrusted with the construction of a provisionary Opera House near the "Porte Saint-Martin."

The Fire of 1788.

The Salle des Menus-Plaisirs had the distinguished honour of receiving the Opera within its walls in 1781.

On Friday, the 18th of April, 1788, fire broke out in the pro-

perty rooms of this theatre, near the forage stores of the King's stables, and rapidly spread over the building. All the King's property was saved, but the stores in the Rue Poissonnière and the Rue Richer were burnt, and the decorations of the Opera, which had been deposited at the Menus-Plaisirs after the fire of 1781, were destroyed by the flames.

No lives were lost on this occasion.

The lesson to be learnt from this fire is as before: if the building had not been all in one risk, the fire could not have spread.

The Fires of 1871.

The Salle de la Porte Saint-Martin was built by Lenoir. It was commenced on the 2nd of August, 1781, and opened on the 26th of October the same year; that is to say, within eighty-six days of its commencement. This house, which had been used for the Opera from 1781 to 1794, was set on fire during the last days of the commune, but it was not totally destroyed. The loss on the building itself was estimated at about 600,000 francs, or £24,000.

The Salle des Machines in the Tuileries, where the Opera, driven away by fires elsewhere, took refuge twice, first in 1763, and secondly in 1781, was destroyed by fire under the commune in 1871.

Owing, however, to the exceptional character of the circumstances attending that dismal time, no lesson can be learned from either of these fires.

The Fire of 1873.

The Opera House in the Rue Lepelletier was built by M. Debret. It was commenced on the 13th of August, 1820, and opened on the 19th of August, 1821. The total cost was 2,550,000 francs, or £102,000. This house was remarkable as being the first theatre in which gas was used.

It was not a well-constructed theatre, but it was supposed to be fitted with tanks, engines, and every appliance for extinguishing fire, and there was always a strong guard of *pompiers* within the building, whether the performance was going on or not.

On the night of Tuesday, the 28th of October, 1873, a fire broke out in this house at a quarter past eleven o'clock, almost exactly the same time as the fire at the Surrey Theatre in January, 1865, and Her Majesty's in December, 1867.

The fire was discovered in the decoration store, which was some thirty or forty feet below the theatre proper.

The regular guard of *pompiers*, consisting of fourteen, were on the spot, and immediately got to work; but the men were overpowered by heat and smoke, and were unable to reach the seat of the fire. A north-east wind was blowing, which drove the flames through the house, and in a very short time the whole building was one mass of fire, and there was no possibility of saving it.

By twelve o'clock the flames were pouring out of every window, and threatening to destroy the whole neighbourhood. At a little after one o'clock in the morning the gigantic lustre came down with a tremendous crash. At about two the ceilings and the roof fell in with a loud report; which was heard at a great distance; and at four o'clock nothing remained of the well-known Opera House but a heap of ruins.

The cause of the fire has not been ascertained, and it may now be presumed that it will never be known with certainty.

The number of engines engaged in extinguishing the fire was as follows:—

In the Rue Lepelletier, 4 manual fire-engines and 1 steam fire-engine; in the Rue Rossini, 10 manuals; in the Cour d'Honneur, on the Rue Drouot, 4 manuals; on the Boulevard des Italiens, 1 steam; and in the Passages de l'Opéra, 7 manuals—altogether, 2 steam and 25 manual engines.

The following is a summary of the official accounts of the losses by this fire:—

About 5,200 costumes were burned, and those saved were injured to the extent of about 60 per cent. of their value.

Fifteen sets of scenery were burned, including the whole set for each of the following, namely: La Juive, Les Huguenots, La Favorite, Le Prophète, Le Trouvère, Don Juan, L'Africaine, Hamlet, Faust, Freischütz, La coupe du roi de Thoulé, La Source, Coppelia, and Gretna Green, and that of the fourth act and two pictures of Jeanne d'Arc. Besides these there were 74 sets of various kinds, of which the frames were at the stores in the Rue Richer, but the upper parts and draperies were burned.

A large number of musical instruments and bells, and one organ, all the property of the State, were destroyed.

The whole of the "property" stores were destroyed, as well as the stage curtains, the oil and gas-fittings, the furniture of the auditorium and saloons, the principal part of the armoury, the electric lighting apparatus, and the fire-service.

Eighteen busts of considerable historic value were destroyed, representing Homer, Molière, Racine, Quinault, Lully, Rameau, Rousseau, Voltaire, Grétry, Glück, Piccini, Beethoven, Philidor, Méhul, Lesueur, Paer, Etienne, Halévy. Some of these were in plaster, among others that of Rameau, the marble of which was destroyed in the fire of 1781, when those of Glück, Lully, and Quinault escaped only to perish now. The loss of the Glück, a magnificent piece of marble by Houdon, is particularly regretted in Paris. Only two months previously this bust and that of Lully were lent to M. Baudry for one of the great drop-scenes which he is making for the new Opera, with pictures of celebrated musicians, and they had been returned by him about six weeks before the fire.

The statue of Rossini escaped the flames, but was broken by falling materials, and was discovered in fragments among the ruins; and the statues of M. Duret, which were in the saloon, were also destroyed.

The estimate of the loss is as follows:—

Building . .	1,000,000 francs,	or	£40,000
Fittings and furniture	300,000 „	„	12,000
Scenery and costumes	1,000,000 „	„	40,000
	2,300,000 „	„	£92,000

From this it will be seen that the building must have greatly deteriorated in value during its short existence.

The only casualty in the way of loss of life was that of Corporal Bellet of the *pompiers*, who was killed while doing his duty bravely, as firemen in Paris always do. This man received the honour of a public funeral at the church of Val de Grace, and a suitable monument is to be erected over his remains.

It is a strange subject for reflection that of all the regular or provisional buildings in which the Paris Opera found a home, there is not one which has escaped a conflagration.

The first Opera House at the Palais-Royal was burned in 1763; the second, also at the Palais-Royal, was burned in 1781; the provisional house at the Salle des Menus-Plaisirs was burned in 1788; those at the Porte Saint-Martin and the Tuileries respectively in 1871; and that in the Rue Lepelletier in 1873.

It is also worthy of remark that all these fires, except, perhaps, those of the commune, broke out in the intervals between the performances from want of sufficient precaution, and that they spread in consequence of bad construction.

The lesson to be learned from all this is, that if a theatre be properly constructed, properly divided, and properly protected, these frightful risks and losses may be avoided.

In conclusion, it is once again repeated that without interfering with any of the legitimate purposes for which theatres are constructed and maintained, it is possible to insure the absolute safety of an audience, and the partial safety of a building and property in case of fire; and it is hardly too much to venture on a prophecy based on the results of practical inspection and observation, that the splendid building known as the "Grand Opéra," now in course of construction by M. Garnier in the Place de la Chaussée d'Antin, will, if provided between the stage and the auditorium with a curtain capable of resisting the effects of heat and flame for about fifteen minutes, attain this desirable object more nearly than any other yet constructed, and that it is likely for years to come to be, in respect of convenience, comfort and safety, the model theatre of the world.

THE CITY COMPANIES, IN RELATION TO TRADE AND MANUFACTURES.

AMONG the chartered or incorporated bodies of this country, few are more remarkable than those which are known as the "City Companies"—wealthy associations, whose luxurious banquets are a fruitful subject of newspaper notice. Although bearing manufacturing titles, they have very little to do with the branches of industry with which they are nominally associated. Possessing large revenues—in some cases princely—many of them maintain almshouses or asylums, and pay annuities or pensions to a limited number of persons; but to the outer public they are known chiefly as the owners of splendid halls, in which costly dinners are given. In a magazine such as ours, we have no immediate concern with them in their civic or festive relations; but there are other considerations which will render a notice of them acceptable. Some of them render a little service in the furtherance of manufacturing industry; others have lately manifested a disposition to do the like; and we will briefly describe what is doing, as a means of showing how much

still remains to be done before the companies can claim to have worthily carried out the intentions of their founders.

In many, if not in most, cases, the companies are the owners of landed estates, comparatively of small money-value originally, but now bringing in large revenues. The terms of the bequests were in several instances so undefined as to leave the companies a free choice in appropriating the annual proceeds; in other instances specific purposes were named, which the companies are bound to fulfil. Between these two extremes the others take rank, morally called upon to do something for the trades with which they are associated by name, but yet so far shielded as to be out of the reach of legal compulsion. This term "morally" is valuable; for there is reason to believe, that if public opinion were brought to bear persistently, but courteously, the companies would gradually show a willingness to effect much which they would obstinately resist if treated threateningly.

Early Days of the Companies.

The companies arose out of the old custom of establishing and maintaining guilds for the protection of every important trade. The commercial theory of those ages was that the public would be cheated right and left, unless there were some authoritative control over weights, measures, and quality. Possibly the theory was well founded; but it unquestionably led to monopoly, seeing that the controllers so managed the contest as to benefit their own pockets, by confining the trade to a favoured clique. When monarchs were short of cash, they would sometimes sell a charter which gave to a guild or fraternity the monopoly of a particular trade; in other cases the charter was granted without fee, in an honest belief that legitimate trade would be benefited thereby. Then, when some one of the merchant-traders waxed rich, he left a sum of money, a field, or a few houses, to the members of his old guild, as a memento of good fellowship, and for the benefit of those who might come after him in the same line of business—with or without precise conditions concerning the distribution of the proceeds. Thus it has happened that the guilds or companies have become possessors of estates the annual rental of which has increased ten, twenty, fifty, and even a hundred fold. Princes, dukes, and generals have become freemen of some of the companies, chiefly on the ground of the halo of antiquity and grandeur which surrounds these corporate bodies, and not at all in relation to the particular trades which are professed to be benefited.

The Weavers were among the first to be incorporated into a guild or company, so far back as the reign of Henry the Second. In the same reign there were nearly twenty other guilds in the city of London, but unlicensed or unchartered, and therefore disowned by the authorities. One guild after another was licensed; and Edward the Third raised the licenses to the dignity of charters, by which they became more valuable in the eyes of the citizens. The king himself, to show the high estimation in which he held these commercial bodies, caused himself to be enrolled as a member of one of them, the Merchant Taylors' Company. The source of their power lay in this: that all artificers and craftsmen within the City were bound to choose each his own "mystery," and not to engage in any other. A "handy fellow," a "Jack-of-all-trades," a man who could "turn his hand to anything," was not welcomed among craftsmen; he had, or was supposed to have, a tendency to poach upon other men's manors. Edward also gave to the trade companies the right of electing the parliamentary representatives for the City, an important addition to their privileges. By the close of his reign, 1377, there were forty-eight companies entitled to send members to the common council: the Grocers, Mercers, Drapers, Fishmongers, Goldsmiths, and Vintners, sent six each; the Saddlers, Weavers, Tapestry-makers, and Butchers, four each; the others smaller numbers.

That the companies, in the early days of their history, exercised formidable power within the range of their own crafts or mysteries, we have abundant evidence. The Goldsmiths' Company, for example, had control over foreign goldsmiths as well as English, if they lived in London; all alike had to pay fees for apprenticeship, for admission into the craft, for licences, and fines. The company acted as arbiter in the time of Edward the Fourth, in a trial of skill between two die or medal engravers; each of whom was to execute two specimens in steel, a die and a counter-die, or an *alto-relievo* and an *intaglio;* the Englishman was adjudged the victor. Many facts illustrate the watchfulness which traders kept one upon another. The goldsmiths complained that foreigners brought into England "counterfeit coin," whereof the pound is not worth above sixteen sols of the right sterling; and of this money none can know the true value but by melting it down. Also many of the said trade of goldsmiths keep shops in obscure turnings and bye lanes and streets, and do buy vessels of gold and silver secretly, without inquiring whether such vessels were stolen or lawfully come by, and immediately melting it down, do make it into plate, and sell it to merchants trading beyond sea. And they make false work of gold and silver, as bracelets, lockets, rings, and other jewels; in which they set glass of divers colours, counterfeiting right stones, and put more alloy in the silver than they ought, which they sell to such as have no skill in such things." The memorial goes on to say that "The cutlers, in their work-houses (workshops), cover tin with silver so subtilly, and with such sleight, that the same cannot be discerned and severed from the tin; and by that means they sell the tin so covered for fine silver to the great damage and deceit of the king and his people." We here find that rogueries, familiar enough at the present day, were practised several centuries ago. The goldsmiths obtained great powers in virtue of a royal charter granted in response to the memorial; dishonesty was checked, but in a manner that gave nearly a monopoly to the members of the guild. They were empowered to inspect, assay, and regulate, all works in gold and silver; to search in any house or even sanctuary; to imprison or fine defaulters; to seize and break up sham or sophisticated jewellery; and to compel the trade within three miles of the City to bring their work to the company's hall to be assayed and marked.

As with the Goldsmiths' Company, so with others; they exercised a direct and often severe control over the crafts with which they were connected. If a young workman were found loitering about idly, it was the duty of the master and wardens of the craft to which he belonged to command him to work for reasonable wages, and, if he refused, to take him before the mayor and aldermen for punishment. If a member of any company were rebellious to its ordinances, by taking unsold wares into the country, or employing "forens" (persons not free of the company), or speaking disrespectfully of its officers—he could be reprimanded or punished accordingly. Safe keeping of trade secrets was a matter closely attended to, and guarded with very stringent provisions for dealing with those freemen who were too communicative to outsiders. The Grocers' Company had an ordinance that no member of the craft should take the house of another member against his wish, or do anything to enhance his rent. Members were not permitted to go to law one with another, until the company had tried conciliation. Apprentices were treated summarily for any misbehaviour. On one occasion an apprentice was brought before the master and wardens of the company to which he belonged; and two men "came in with twopenny worth of birchen rods, and there, in the presence of the said master and wardens, without any words speaking, they pulled off the doublet and shirt of the said John Rolls, and thereupon (being naked) they spent all the said rods." The ironmongers' apprentices were enjoined to wear plain and useful clothing when at work, and not to suffer their hair to grow long. The fishmongers' apprentices were directed to wear a gown in the fish market, but not out of it. The searching at the shops of traders was a regular privilege of the companies. Such was that exercised by the grocers or pepperers over all the sellers of powders, confections, plaisters, ointments, and other things which we certainly do not now include under the name of groceries. The Fishmongers' Company examined fish; the Vintners' tasted the wines offered for sale; the Merchant Taylors' examined and measured cloth; while the Wax Chandlers' were empowered to examine "torches, all torchettes, tapers, prykettes, and other manner of chandlerie of wax," to see that they were made of good wax, and not wax mixed with rosin. As to the Stationers' Company, their functions in the first instance were rather to keep down books than to encourage their production. One printer had the monopoly of bibles and prayer books, a second of law books, another of A B C's and catechisms; a fourth, of almanacs and prognostications, and so on. These departments of printing and publishing had, for the most part, been open to the trade, or confined to the Stationers' Company, down to the time of Elizabeth, when monopolies were sold right and left to the best bidder. After many changes the company settled down to the profitable business of publishing almanacs and registering books under the Copyright Acts.

The companies increased greatly in number and in wealth during the fifteenth and sixteenth centuries; but when, in the second half of the seventeenth, Charles the Second interfered with their pet privileges (many of which had become literally and solely monopolies), a process of sifting began; the weakest gradually died out, leaving the stronger and wealthier to maintain their position.

Classification of the Companies.

Newspaper readers are little aware how numerous are these companies, and how apparently trivial are the trades with which some of them are by designation associated. Many of the

trades have departed from London long ago; others have even gone entirely into oblivion, in the provinces as well as in the metropolis. As a curiosity we give a list of eighty-eight companies, all of which possessed charters; some in the list have ceased to exist, and others we should find some difficulty in ferreting out, even with the aid of a Directory. A few are so poor that they can only just have a dinner on Lord Mayor's day; while one company actually consisted at last of only one individual, whose death was the company's death. All the companies have definite order, rank, or precedence, being headed by those which are known as the *Twelve Great Livery Companies*:—

1. Weavers.
2. Grocers.
3. Drapers.
4. Fishmongers.
5. Goldsmiths.
6. Skinners.
7. Merchant Taylors.
8. Haberdashers.
9. Salters.
10. Ironmongers.
11. Vintners.
12. Clothworkers.

Then come the less-dignified companies:—

13. Dyers.
14. Brewers.
15. Leathersellers.
16. Pewterers.
17. Hatters.
18. Cutlers.
19. Bakers.
20. Wax chandlers.
21. Tallow chandlers.
22. Armourers and braziers.
23. Grinders.
24. Butchers.
25. Saddlers.
26. Carpenters.
27. Cordwainers.
28. Painter-stainers.
29. Curriers.
30. Masons.
31. Plumbers.
32. Innholders.
33. Founders.
34. Poulterers.
35. Cooks.
36. Coopers.
37. Bricklayers.
38. Boyers.
39. Fletchers.
40. Blacksmiths.
41. Joiners.
42. Woolmen.
43. Scriveners.
44. Fruiterers.
45. Plasterers.
46. Stationers.
47. Broderers.
48. Upholders.
49. Musicians.
50. Turners.
51. Basket makers.
52. Glaziers.
53. Hosiers.
54. Farriers.
55. Paviours.
56. Lorimers.
57. Apothecaries.
58. Shipwrights.
59. Spectacle makers.
60. Clock makers.
61. Glovers.
62. Comb makers.
63. Felt makers.
64. Framework knitters.
65. Silk throwers.
66. Silkmen.
67. Pin makers.
68. Needle makers.
69. Gardeners.
70. Serge makers.
71. Tinplate workers.
72. Wheelwrights.
73. Distillers.
74. Hatband makers.
75. Patten makers.
76. Glass sellers.
77. Tobacco-pipe makers.
78. Coach and harness makers.
79. Gun makers.
80. Wire drawers.
81. Long bowstring makers.
82. Playing-card makers.
83. Fan makers.
84. Wood mongers.
85. Starch makers.
86. Fishermen.
87. Parish clerks.
88. Carriers.

Which of us, now-a-days, knows the meaning of such handicraft trades as cordwainers, boyers, fletchers, broderers, throwers, lorimers; and who would expect to find in London corporate bodies representing, or supposed to represent, cloth workers, barbers, armourers, scriveners, musicians, framework-knitters, pin makers, needle makers, patten makers, and long-bowstring makers? Some, as we have said, are extinct; the rest are nearly eighty in number.

When the affairs of the City companies were investigated by a royal commission some years ago, it was found convenient to classify them into groups:—1. Companies still exercising an efficient control over their trade, such as the Goldsmiths and Apothecaries. 2. Companies exercising the right of search or marking, such as the Stationers, Gun makers, Founders, Saddlers, Painters, Pewterers, and Plumbers; the Stationers exercise much influence in regard to the registration of copyright, but the duties of the other companies now exercised are very slight; the Goldsmiths and the Apothecaries belong to this group, as well as to the first. 3. Companies into which persons carrying on certain occupations in the City are obliged to enter; these comprise, besides a few belonging also to the other groups, the Brewers, Builders, Barbers, Bakers, Painter-stainers, Innholders, Poulterers, Cooks, Weavers, Scriveners, Farriers, Spectacle makers, Clock makers, Silk throwers, Distillers, Tobacco-pipe makers, and Carriers. It is said that only three of the companies confine membership to persons in the specified trades; the others admit any or all trades, through the operation of gift or purchase, as distinguished from birth or apprenticeship. The present Lord Mayor, for instance, is a member of two companies, neither of which corresponds with the trade he carries on as a ship-provision merchant.

Present Proceedings of the Companies.

It was an annoyance to the companies to be told in the report of the commissioners that they are "in effect mere trustees for charitable purposes or chartered festivals;" that "the freemen and liverymen, or commonalty, are persons entitled to participate in these charities, to partake of the feasts of the company, and qualified to be promoted to the office of trustees; and in this light alone are the different orders of the companies to be viewed." It was annoying, but it was true in all save a small number of companies.

Of the twelve great livery companies, we are not aware that the Mercers, Grocers, Drapers, Fishmongers, Skinners, Merchant Taylors, Salters, Ironmongers, or Vintners adopt any direct means for encouraging or improving the trades to which they severally belong. Of the other three, and of some of the minor companies, we may usefully make a few observations in connexion with a recent important movement in industry and manufactures. The establishment of Annual International Industrial Exhibitions has had something to do with the awakening of the City Companies. The Commissioners conceived that such Exhibitions would form a kind of nucleus for technical education among our skilled artisans. Different branches of industry being illustrated in successive years, each Exhibition might serve as a school for a different set of artisans. Our workmen are well skilled in the rule-of-thumb details of their own trades; but they are imperfectly acquainted with the scientific principles on which the rules rest, and with the artistic development of beautiful combinations of colour and form in articles of manufacture; moreover, they have much to learn concerning the state of industrial skill in continental countries. As a means of furthering this knowledge, the royal commissioners sought the aid of some of the City Companies to bring the object under the immediate notice of members of the several crafts. This it was proposed to effect by the encouragement of exhibitors, by the offer of prizes, honours, &c.; and by sending selected bodies of artisans to study at the annual exhibitions. We shall now briefly show how far this appeal, and a similar one from the Society of Arts, have been responded to.

The *Goldsmiths'* Company exercise a supervision in regard to the quality of the precious metals worked up into plate, jewellery, watch-cases, &c. The "Hall-mark," impressed by the company's officers on the manufactured articles after assaying or testing, is held as a guarantee that the gold or silver is good—not pure or without alloy (for it would then be too soft to render the required amount of service), but with a proportion of alloy not surpassing a certain limit. The company have nothing to do with the beauty of the design, the excellence of the workmanship, or the price at which the article is sold; they introduce no new patterns or new materials, no new tools or new processes; they simply test the precious metals employed, and give their stamp as a guarantee of quality. Once every year or two, at the request of the government, and in connection with the provisions of a very old charter, they test the gold and silver employed in the coinage, as a part of the ceremony known as the Trial of the Pyx. In recent years the company have occasionally taken part in promoting exhibitions or displays of glittering plate; and when the jewellery section of the Annual International Exhibition of 1872 was in preparation, they made a decided step in the right direction. They offered prizes to "encourage technical education in the due execution of works of art in precious metals." The conditions were as follows:—"An annual prize of £50 for the best design for some article in gold or silver which, when manufactured, shall exceed 30 oz. in weight; an annual prize of £25 for the best model of some such article as aforesaid; and an annual prize of £25 for the best execution and workmanship of some such article as aforesaid. Also three annual prizes of £25 each for (1) the best design, (2) the best model, and (3) the best execution and workmanship of some article of gold or silver, which, when manufactured, shall be less than 30 oz. in weight. Also three annual prizes of £25 each for the best specimen (1) of chasing or *repoussé* work, (2) engraving, and (3) enamelling in the precious metals. Originality is necessary for obtaining either of the prizes for design, and no copy shall be the subject of a prize. The prizes will be awarded in November. It has also been decided to form a travelling scholarship of £100 per annum, to be awarded by the wardens to a student who has shown exceptional talent, and who has obtained a prize for design for three successive years, in order to enable him to study art in the

precious metals on the continent." This, it will be seen, is an encouraging proceeding, not large in reference to the great wealth of the company, but in the right direction, and calculated to bring about good results eventually.

The *Stationers'* Company have nothing to do with the literary merit of the new books which they register, and which are said to be "Entered at Stationers' Hall;" neither do they foster any particular improvements in paper-making, type-founding, printing, book-binding, or the other arts connected with the production of books. They receive fees, as we have already said, for the registration of new books, and profits from the sale of several almanacs of which they are the owners and publishers. Recently, however, the Stationers' Company have entered the list of those which evince a desire to move a little beyond the wonted groove. They have given lectures at the hall near Ludgate Hill, on subjects interesting to printers. These lectures, by Mr. Ellis A. Davidson, embraced the arts of printing, type founding, paper making, steel and copper plate engraving, lithography, and wood engraving. Such was the programme. In response to invitations sent to the several London firms, two thousand five hundred operative printers attended, in parties as large as the limited capacity of the hall would permit. The affair is small, but, like other good things, it may be the forerunner of useful results.

The *Painter-stainers* are not a company concerning which the public possess much information; yet have they achieved something praiseworthy which might be well imitated by corporations of greater wealth and notoriety. We know, in the present day, what a painter and grainer means, and what a paper-stainer or paper-hanging manufacturer means; but a painter-stainer is not now a recognized designation in actual trade. It really means a decorative painter. The company thus designated was formed at a time when artists and decorative painters were regarded nearly on the same level; real artists were willing to employ a portion of their taste and judgment in the decorative painting of saloons, rooms, churches, and public buildings. The company are not a little proud to have in their books the names of Cornelius Jansen, Samuel Aggas, Sir James Thornhill, Sir Godfrey Kneller, Antonio Verrio, Van der Meulen, and Sir Joshua Reynolds as among the members in bygone ages. Indeed, it is hardly too much to say that the Painter-stainers' Company were the precursors of the Royal Academy. Mr. Sewell, master of the company in 1860, addressed a circular to the trade, in which he frankly stated that the old City companies had pretty nearly outlived their original purpose, and he invited the decorative painters to the consideration of a plan for striking into a new path, so far as that particular company was concerned. "The powers of the various guilds are not maintainable under their bye-laws; and it must be acknowledged they have fallen into desuetude, and operate in restraint of trade. I consider, however, that by substituting emulation for coercion, the guilds (especially those in which skilled handicraft is required) might yet maintain, as bodies, a firm and useful position in society. My suggestion for effecting this, as relates to this company, consists in inviting the workmen, artificers, and artists connected with painting and decoration, to submit their work annually to public inspection, their merit to be judged by competent persons." The first of these exhibitions was held in the year above-named, and was brought under public notice in a sensible announcement:—"Without vainly seeking to compete with the national institutions which exist for the encouragement of the fine arts, the Painters' Company conceive they act in full accordance with their vocation, and with the spirit of the age, in endeavouring to give an artistic impetus to the more mechanical of the decorative arts; and, as far as is practicable, reuniting them with the higher branches of the art and mystery of painting." The first exhibition was warmly praised by the press, but not much visited by the public. Few people knew where Painter-stainers' Hall is situated, and of those who ascertained, a still smaller number were tempted to plunge into the pent-up and dismal region around Garlick Hill and Little Trinity Lane. A second exhibition, in 1861, was aided by the Society of Arts, which contributed to the prize-fund; and it was also agreed that those members of the society noted for their knowledge of decorative arts should join three members of the company and two exhibitors chosen from among that body, to form a court of judges, to adjudicate on the merits of the articles exhibited, and to award prizes. The company adopted the following classification of merits and rewards:—Silver medal, and the freedom of the company, to each of four competitors in the first class; bronze medal to each of four in the second class; and certificate of merit to each of four in the third class. The specimens exhibited related to graining, marbling, inscription writing, and arabesque painting. Technical skill was abundantly displayed; but the art-judges deemed it proper to declare that there was a deficiency in artistic feeling, showing the necessity for further study from good models. The Society of Arts warmly approved the movement made by the Painter-stainers' Company, expressing their conviction that "the project is capable of valuable extension, and may serve to indicate to other corporations and independent public bodies an opening whereby, through similar or analogous means, they may renew that usefulness which time, in some measure and in some particulars, has somewhat impaired." In 1862 the company confined their operations to awarding prizes to some of the decorators who sent specimens to the International Exhibition; but the annual series at Painter-stainers' Hall was renewed in the next following year.

The *Clothworkers'* Company are among those which are somewhat puzzled how to advance the branch of industry associated with their privileges and duties in times long past, seeing that not a yard of woollen cloth is now made in the good city of London. In a conference held at the house of the Society of Arts (presently to be noticed), relating to technical education, Mr. Bloxam, as representative of the Clothworkers' Company, made some observations curiously illustrative of the wide gap which in many instances separates the companies from the trades. He stated that his company were willing to do something; but that the annihilation of the trade in London had perplexed them. They proposed to send to the West of England and to the West Riding of Yorkshire to ask the *real* clothworkers of those districts in what way the company could assist in fostering this branch of industry.

The *Coachmakers and Coach Harness Makers'* Company are endeavouring to infuse a spirit of honourable competition among the workmen in those trades by means of occasional exhibitions held in the company's hall, and by the distribution of prizes. The prizes, silver and bronze medals, are awarded to the most efficient competitors in free-hand drawing, geometrical mechanics, drawings of carriages and parts of carriages, &c. The competition is open to all branches of the two trades, and to natives of any part of the United Kingdom, not merely to City workmen. It may be remarked that at the adjudications both of 1872 and 1873 the judges commented on the deficiency in artistic invention and grace in the designs exhibited, corroborating a well-known fact, that our skilled artizans, however clever mechanically, have still much to learn in the artistic element which should never be absent from manufacturing industry. One of the curiosities of our City companies was the admission of His Royal Highness the Duke of Edinburgh as a freeman of the Coachmakers and Coach Harness Makers' Company. On the occasion of the presentation of the freedom (Feb., 1873) the Royal Coachmaker very sensibly said, "The power which such a body possesses in aiding and stimulating the efforts of those who seek to encourage technical education among our artizans cannot be over-rated; and I am glad to think that the influence of this company has been thus exercised. There are some among you who may remember a conference held by the Society of Arts last year, under the presidency of my brother, Prince Arthur, when a scheme was suggested, showing how the resources of the great City companies might be most beneficially applied in that direction. I trust that the labours of that conference may have the success they deserve."

The *Haberdashers'* Company can hardly be considered a manufacturing guild; even in the old times, it was probably a fraternity of shopkeepers, favoured with certain privileges in the sale of miscellaneous haberdashery goods. Be this as it may, the company are willing to aid in a useful way, in a similar spirit to their neighbours, the coachmakers. But how? It is really amusing to look at a sketch of some of these City companies when drawn by one who is in the best position to form a judgment. Mr. Campin, representing the Haberdashers' Company at the Society of Arts conference, said, "The guilds of the city of London, of one of which I am a member, have now got into this position, that they are no longer associations of men practically conversant with the arts whose names they bear, as was the case at one time. Mr. Watney (one of the previous speakers) is, I believe, not a mercer, although he belongs to the Mercers' Company; and I myself am not a haberdasher, nor was my father, although both have belonged to the company. There is no doubt that these companies possess wealth, and that it is their duty to advance the education of the workmen in their respective trades, and I believe they would be willlng to do so if the case were put before them in a proper way. The workmen also should be consulted, because now-a-days they are not represented in the guilds as they used to be. Formerly a guild consisted of masters, workmen, and apprentices. It is not so now. I think it would be well if they associated themselves with the Society of Arts in a similar way to the institutions for science. They do not consist of practical men who can deal with this question. For instance, the Haberdashers' Company lately offered a prize of one hundred pounds for the best invention in

haberdashery, but they had to go outside their body to find a gentleman to decide on the inventions submitted."

The *Joiners'*, the *Turners'*, and the *Brass Founders'* companies are among those which have made laudable, though small, attempts to further the interests of those trades, by means of prizes or exhibitions, or both combined.

We have more than once mentioned a conference in relation to the Society of Arts; and it will be well now to explain its nature and purpose, seeing that some of the City companies took part in it. On the 20th of July, 1872, an influential body of persons assembled to advocate the establishment of technological examinations, which are not comprised in the proceedings either of universities or of the Education Department of the Government. It was proposed to make the Society of Arts the central link, but to seek the aid of the various guilds, companies, and corporations, and also of the Science and Art Department. The latter would examine pupils in general progress, while the society would examine in technology, and reward with prizes, the expense of which the guilds might possibly be induced to share. A definite plan was proposed by Major Donnelly, R. E. Three grades of examination would be founded: 1. The elementary grade, for workmen artificers. 2. An advanced grade, for foremen artificers. 3. Honours for the highest degree of competency. Five committees of the Society of Arts were formed, comprising members more or less versed in five different branches of manufacturing industry. The annual international exhibitions being in progress, and being intended for regular continuance, it was proposed that the technological examination for each year should be in the principal subjects included in that year's programme at the Exhibition. The international display for 1873, as we know, has comprised silk, steel, and carriages; in 1872 cotton and paper were two of the subjects, and it was decided that those five subjects should be taken up anterior to any others. The Society offered, out of its own funds, three prizes of £10, £7, and £5 each to the three best candidates in each of those five classes. The commissioners of the Great Exhibition of 1851 (who are also commissioners for the present annual exhibitions) offered prizes of £50 for the best competitors in three of the above-named classes, viz. silk, steel, and carriages, on condition "that the recipients go for a year to some place of scientific instruction, such as the Royal School of Mines, the Royal College of Science in Dublin, Owen College at Manchester, or the English, Scottish, or Irish universities, or other school approved by Her Majesty's commissioners, or travel abroad for the purpose of improving themselves in their trades." Mr. Portal offered prizes in connection with the paper manufacture, and Mr. Hooper in connection with carriage building. The Spectaclemakers' Company, probably considering that the making of spectacles might safely be left to itself, resolved to extend their help so as to embrace steel generally. They offered three prizes to the second best in each of the three grades in steel manufacture (leaving the really best to try for the commissioners' prizes). Seven of the City companies, viz. the Fishmongers, Mercers, Drapers, Vintners, Salters, Clothworkers, and Coachmakers, contributed to the general fund, without offering specific prizes. It has since been decided to take up some of the subjects in the annual international programme for 1874, and combine them with some in the past programmes of the three preceding years, thus comprising the subjects of woollen manufacture, pottery, cotton manufacture, paper-making, silk manufacture, steel manufacture, carriage building, and glass manufacture, to hold examinations on those subjects, and to award prizes in 1874.

Thus a good beginning has been made, in which the City guilds take a part, albeit a small one.

The Society of Arts have been instrumental, with the commissioners of the Exhibition and (we believe) the Coachmakers' Company, in encouraging a new build of street cabs. The competitors showed their inventions at the recently closed Exhibition, the best among them received medals and money prizes, and the Prince of Wales has encouraged the movement by ordering one of the improved vehicles for his own use at Sandringham. We may also mention, in connection with the gold and silversmith trade (already touched on), that the Society of Arts have undertaken the examinations necessary for the award of a prize of £25 offered by Mr. Streeter for the best essay on hall marks, with suggestions for the improvement of the system of hall-marking.

THE MANUFACTURE OF GOLD, PLATINUM, AND SILVER, IN LEAF, SHELL, AND POWDER.

By the Firm of Goguel and Co., successors to Favrel and Co.[1]

GOLD, in addition to its indestructibility and brilliancy, can boast of a peculiar property—ductility—which it possesses in a degree far superior to that of all the other metals; for from gold we are able to make sheets or leaves infinitely thinner than from any other natural body, and yet able at the same time to preserve a certain tenacity. This faculty has given rise to an industry which from day to day, in spite of all the progress of electroplating, becomes more prosperous; for even at the present time of writing, the gilder prefers to affix leaves of gold, thinner or thicker, on the various metals; and as to paper, cardboard, or wood, it has up till now been difficult to treat these substances with the ordinary processes of galvanization. The ancients, from times the most remote, were acquainted with the art of reducing gold into thin leaves, and the Romans covered not only the walls of their temples, but even the walls and ceilings of their private rooms with gold. The thickest sheets were termed *Prænestinæ*, because it was with leaves of this sort that the statue of Fortune, at Preneste, had been gilded. The thinnest leaves were called *questoriæ*; all bore the name of *bracteæ*, in opposition to the *aurum solidum*, that is to say, thick gold, which was employed in rich incrustations. The use of these different kinds of gold-leaf was widely spread, and the historians relate, without any feeling of astonishment, that Nero caused the whole interior of the theatre at Pompeii to be gilded for the single day, when a feast was offered to Tiridatus, king of Armenia. The Roman workmen never drew more from one ounce of gold than 750 leaves of a square measurement of the breadth of four fingers; now we are able to make more than double out of the same weight. Not, however, because the processes employed have been much improved, for the necessary thinness of metal is still obtained by hand-beating, and each leaf sold to the public has received about 18,000 blows from mallets wielded manually.

If we consider the other metallurgical industries with their prodigious apparatus of steam-hammers and rolling-mills of all sizes and all powers, it seems altogether singular that we have not yet arrived at the automatical production of beaten gold. The founder of the concern which we are going to first describe did invent a mechanical beater, and was rewarded by a medal of the first class in the Exposition of 1855, but up to the present date he has not been able to bring it into every-day use. We shall see, in following this study, what other important improvements have been brought by M. Favrel to bear upon every detail of his trade—improvements which gained the house the gold medal at the Exposition of 1849, and two medals of the first class in 1855. A few years ago the former partners of M. Favrel ceded their establishment to two former pupils and assistants, MM. Henri Goguel and Philippe Eberlin, who, under the title of Goguel and Co., continue the manufacture on the same principles as those of the founder, who had knowledge and power sufficient to give his establishment a place altogether exceptional in his art.

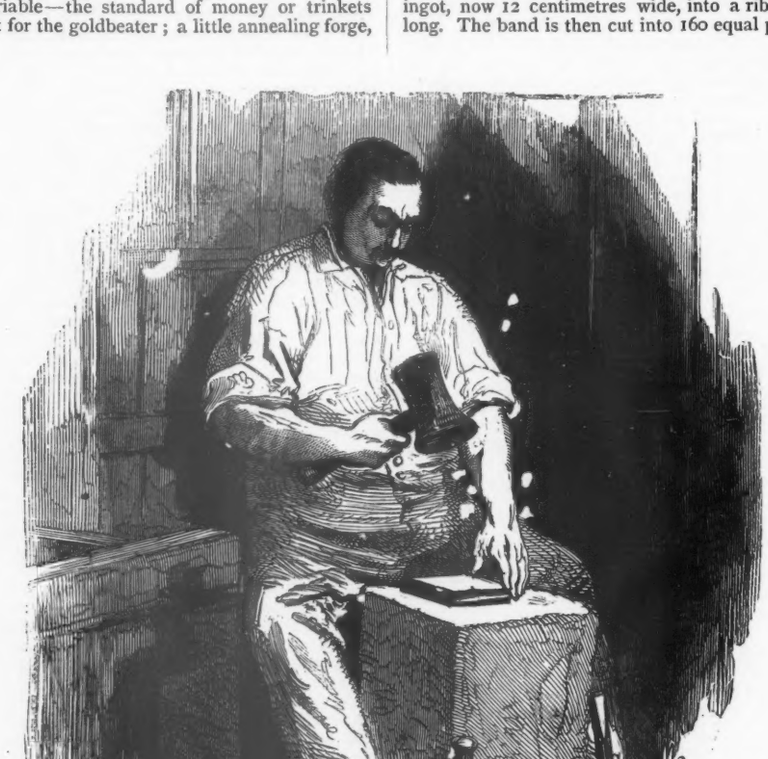
The workshop is situated in the Rue du Caire. On first entering it is easy to see that we have penetrated into a sanctuary of the precious metals. Everywhere there are gratings and scales; on the ground there are oak gratings, keeping the feet from the boarding, and allowing lost fragments of the rich material employed to be easily recovered. In the centre, and on the ground-floor, we see a large hall, lit from above, in which the gold-beaters are working; along the sides, on the ground-floor, and on the first-floor, stand the tables where the workmen handle the leaves, either in course of manufacture or at the moment of preparation for sale. In the buildings behind we find a series of different instruments intended either for working with the goldbeaters'-skin, or for the collection of the gold fallen into the screens. Before visiting these different parts of the establishment, it is necessary to say a few words upon the problem that the gold-beater has to resolve, and to point out what are the principal tools he uses to arrive at that end.

Given then an ingot of pure gold, he has first to colour it, by a slight alloy, a yellow or red, paler or darker as the purchaser may desire. Next he has to reduce it to a sheet so thin that it

[1] Translated from "Les Grandes Usines," by M. Turgan.

may have the least possible quantity of metal for the greatest surface, and yet to take care that the sheet shall have sufficient resistance to be employed without falling into powder under the tools of the gilder. It is necessary also that it should entirely intercept the light—that is to say, that the continuity of the metal should be absolute. In badly prepared leaves a crowd of little holes perforate the metal, and the substance which has been gilded with such foil would be rapidly attacked by air and moisture.

The instruments used to bring about this result are, in the first place, and as a matter of course, a crucible in which to melt the metal, to which alloy has been added in proportions that have not varied for the last half century; this proportion should be infinitely little, for gold too strongly alloyed becomes hard, sharp, and friable—the standard of money or trinkets would be insufficient for the goldbeater; a little annealing forge, accompanied by a dressing-stake or beak-iron, on which the forger hammers the just melted ingot until it is cold. These ingots are not stamped or marked, because the fineness of the leaf itself is the truest guarantee of the purity of the metal, and yet there are about twenty qualities and forty tints; some are distinguished among the rest by their colour, citron, green, red, white, &c.; others, termed demi-yellow, yellow, deep yellow, superfine yellow, differ one from the other in their relative purity. When the forger has verified the weight of his ingot, he spreads it out until it is about 6 centimetres wide; he anneals it, then passes it through a rolling mill composed of two cylinders of German cast-steel, sustained by two others of cast-iron. A series of successive rollings, graduated according to the nature of the gold, and tempered by two annealings, draw the ingot, now 12 centimetres wide, into a ribbon about 15 metres long. The band is then cut into 160 equal parts.[1] After placing



THE GOLD-BEATER.

these 160 one upon the other, the forger strikes them with his mallet, squares them, equalizes them, and anneals them once again; these 160 morsels, termed "quarters," after having been beaten, gold upon gold, are now introduced into a series of "tools," the theory of which is the same, but the material different. The first is styled the *caucher* (mould), and is a kind of book open at all the sides, and composed of 160 leaves of parchment paper, cut 105 millimetres square; 40 other such leaves, but blank, named *emplures*, surround the rest, they receive no metal between them, being only intended to soften the fierceness of the blow from the mallet. The old *cauchers* were made of vellum; the parchment paper employed to-day is a kind of goldbeaters' skin, manufactured by MM. Montgolfier at Annonay. Each *caucher* is divided into two equal packets by a certain number of *emplures;* the whole book is surrounded and squeezed tight by a case of parchment fastened with gum arabic. This case should be large enough to allow the *caucher* to be easily introduced, and yet sufficiently tight to keep all the leaves perfectly parallel. The goldbeaters like to make these covers or sheaths from old parchments, which were much better prepared than those of the present day, and thus many missals and precious manuscripts have been, and will be, pitilessly wasted, until a good substitute be discovered.

Between the leaves of the *caucher*, right in the middle, and one upon the other, are placed the 160 quarters cut by the forger, who puts his "tool," thus filled, upon a kind of square block of stone, and with a mallet commences the beating. The blows are not, as one might think, given at haphazard; either from simple habit or methodical experience, all the beaters beat in a uniform manner. Thus, they give the name of *main* to 24 blows, struck one after the other, either with the right hand or the left, and divided equally between the two sides. At every *demi-main*, that is to say, every 12 blows, the tool is turned. The mallet-blows are distributed methodically not only in their number, but even in their direction. Thus, first of all, the mallet strikes one blow in the middle, then two to the right, while the forger

[1] 150 is the usual number in the English manufactories.—H. C.

WORK GIRLS EMPTYING AND FILLING THE GOLDBEATERS' TOOLS.

turns the tool so as to present the four corners of the gold equally to undergo the percussion. In this first operation the workman does not give more than from nine to ten *mains*, according to the nature of the gold.

These precautions always tend to the same end, that is to say, to thin and spread out each quarter in an equal proportion without overheating the metal or the tool itself, which would then be completely destroyed. During the whole of the operations it is essential to pay the utmost attention to the heat developed, which, for long after extraction from the tools, is preserved in the leaves.

When the first *caucher* is sufficiently beaten the forger empties t himself, fastens his gold with an iron wire, anneals it, and carries it to the office, where the scales prove that the packet has preserved its original weight.

The forging thus terminated, the beating proper begins. Before this operation the 160 quarters are divided into two parts, each of 80 quarters; and these 80 quarters are cut into four equal parts, producing, consequently, 320 little quarters, placed by the workmen in a second *caucher*, made exactly like the first, only that it has 320 leaves instead of 160. The 160 quarters in the first *caucher* have now become 640 in the two second *cauchers*.

The metal is again weighed at the office, from which the beater receives his *caucher* ready garnished; he strikes upon the tool like the forger, only he takes the precaution of girding his loins with a leather apron, the end of which is fastened upon the stone block; this he does because his mallet-blows at the end of a certain time cause the gold to sweat through the edges of the *caucher*. He strikes two blows in the middle and four upon the edge, making the tool turn, and re-turning it every *demi-main*, then taking it out of the cover and changing the position of the two parts composing it, so as to place the top at the bottom and the bottom at the top. With certain qualities of gold, and in a similar proportion for all other qualities, each of these *cauchers* contains 250 grammes of gold, that is to say, the half of the 500 grammes returned by the forger in the shape of quarters. When the workman has driven a weight of about 50 grammes out of his tool, he deposits these 50 grammes in a tin box, marked and numbered, in which all the fragments from the ingot bearing the same number are placed; he takes the tool back; they weigh the leaves, which should represent 200 grammes, in spite of a loss calculated at some centigrammes. Each of the 320 leaves is then cut into four parts, producing 1,280 little quarters, which are placed in another tool, termed the *chaudret*.

To accomplish these divisions, and this transport of the leaves of gold, the work-girls place them upon a cloth cushion covered with skin, and slightly raised in the middle. They take hold of the leaves in the *caucher* with long pincers of spindle-wood, the only wood so compact that its pores do not retain any of the gold, and to be replaced only by ivory itself. The girls also use very solid sliding-tongs, which, with either the *caucher* or the *chaudret*, and later on with the *mould*, form a kind of provisional binding, which allows the workmen to open the leaves one by one without any escaping. With the spindle-wood pincers the work-girl then takes out the quarters; she rests them on the cushion and cuts them into four parts, equal in size and square in form, and with the same pincers she next places them in the *chaudret* (or mould of gut) so that each square exactly covers the preceding one placed in the middle of the first leaf after the *emplures*.

The *chaudret* is the first "tool" where the parchment-paper is replaced by goldbeaters' skin. Before describing the operations executed with this implement, we had better explain the nature of goldbeaters' skin, and rapidly set forth the operations essential to render it serviceable and to keep it in a condition fit for use. Goldbeaters' skin is a leaf composed of two sheets made with the serous membrane which surrounds the intestines of an ox exteriorly. This membrane, very fine, very equal, and extremely resisting, unites so perfectly on its interior face with the interior face of a membrane of the same nature, and the adhesion becomes so intimate, that the two appear to be one and the same sheet. All the world knows this substance, so light, so slight, so tenacious, and so perfectly dense, that when dried it can retain the subtlest gases. Its preparation is extremely protracted and difficult, and up to the present the English manufacturers bear the palm away from ours.[1] It is a very costly material, and a packet of these leaves, bought new, comes to nearly 300 francs; but the goldbeaters' skin can never be employed in the new state. It contains too many fatty substances, too many inequalities; it would damage the gold, and the bubbles between the two pellicules would break the leaves.

[1] *Translator's Note.*—According to Dr. Lewis, the preparation of goldbeaters' skin is only practised by two or three persons in the United Kingdom.

They begin by smearing the goldbeaters' skin with a varnish composed of wine, alcohol, and spices, spread on with a pencil; they cut it, square it, beat it dry, and burnish it; then they practise on the packet of leaves with a first beating of silver, which thins the membrane; next they beat with gold completely pure, or with the green gold containing silver. After a certain number of these beatings, the goldbeaters' skin is ready for actual use.

Formed into a *chaudret* composed of from 1,250 to 1,300 leaves to receive the metal, and of fifty others to act as *emplures*, it is handed over to the beater with a ticket indicating the number of grammes he has to beat out and return in the form of waste or fragments. The original ingot of 500 grammes divided into two parts has already lost twice 50 grammes of waste; it must, in passing through the *chaudret*, lose another hundred grammes in waste. It will then be reduced to 300, divided into two parts of 150 each. When the beating is finished the tool ought to be perfectly square, of an equal thickness every way, without the borders at all projecting. They brush the edges so that the gold may be more easily detached, and return the full *chaudret* to the work-girls, who empty it, and at once place the leaves in another tool of the same nature as the *chaudret*, also made of goldbeaters' skin, and termed the *mould*. The *chaudret* and the *mould*, when they have been used, and before being employed anew, require two extremely important accessory preparations—burnishing and pressing. What we are going to say of one of the tools equally applies to the others, all being composed in the same way.

The goldbeaters' skin of which they are formed is hygrometric in the highest degree, *i. e.* it absorbs with avidity the least trace of water contained in the atmosphere; it then becomes soft, swollen, and adhesive, and can no longer be used for beating. The ancient goldbeaters eliminated this dampness by placing their tools under a press heated by a furnace; often the heat over-passed the point of resistance of the goldbeaters' skin, and roasted it like any other animal matter. M. Favrel applied steam to drying the tools; he made a dryer formed of six or eight presses, fastened each of them upon a hollow box of cast-iron, in which the steam circulated by means of elastic serpentine copper tubes. When pressure was applied to compress the tool, the tubes yielded and fell back, and in like manner came forward when the pressure was taken off. The tools are not placed directly in contact with the iron; two pieces of strong cardboard and some sheets of paper separate them from the plates of the press. After ten minutes' exposure to heat, the tool is gently handled, so as to make the goldbeaters' skin leaves slip one under the other and destroy the folds. After being *handled* the *chaudret* or the mould is returned to pass another five minutes under the press; it is then necessary to cool them. Formerly this cooling was done by holding the leaves in the right hand, and rapidly passing the left hand over the edges, to separate one leaf from another, and thus produce, in some sort, a current of air. M. Favrel tried the simple but very just idea of applying the wind from a pair of bellows, like those seen attached to the little portable forges; the wind thus raised enters between the leaves, separates one from the other, and cools them all. These preparations of the goldbeaters' skin are renewed oftener or less frequently, according to the temperature, and especially according to the hygrometric state of the atmosphere. Strong frosts and an east wind are very favourable to drying; rains and sultry weather sometimes necessitate as many as six or eight attempts before a satisfactory result is obtained. After leaving the press the tool ought to be tested by heating three or four quarters of gold in the middle of its leaves. At the end of five or six blows from the mallet the quarter should *suck*, that is to say, should adhere to the leaves of the tool. If it does not suck it has again to be submitted to the press.

Another very long operation is that of planing, which effects a restoration of the tools. This is done by placing the used goldbeaters' skin in a large book of parchment, damped with a sponge soaked in vinegar, it is then inserted in the *plane*, a kind of vellum tool, which also is beaten, pressed, and dried. When the mould has undergone this planing it is said to be a fresh mould.

Before receiving the quarters that have already passed through the *chaudret*, the mould, like the *caucher* and the *chaudret*, has to be burnished, that is to say, has to be covered with an impalpable dust obtained by calcining, pulverizing, and sifting transparent gypsum. M. Favrel was not satisfied with the old process, which consisted in shaking by hand-labour an instrument called the *marmotte*, hung up in the middle of the workshop, and from which the gypsum powder escaped; so he invented a sifter, in which a bagful of pulverized gypsum, or *brown* powder, as the goldbeaters term it—we know not why—is struck by rods put in motion by a transmission from the steam-engine. This brown powder is spread over the goldbeaters' skin with a hare's foot by a work-girl who takes about an hour in burnishing a mould of 1,250 leaves. When the

mould is new or fresh a fine burnish, thick and warm, is put on to thin it and dry it, and after having got rid of a certain quantity of this first brown powder, by a few turns under the press, they give it a second burnish, light and cold, before handing it over to the work-girl whose duty it is to fill it.

This work-girl, who has received the 1,280 leaves issuing from the *chaudret*, has cut them into 5,120 little quarters, which will now fill four moulds of 1,280 leaves each. The mould is composed of leaves 13 centimetres square. It is much larger than the *chaudret*, and is essentially the tool of the goldbeater proper. To beat it correctly is the most difficult task in the whole profession, unattainable by a large number of workmen who are skilful at beating the *caucher* and the *chaudret*. The beating of the mould is divided into two parts—*rounding* and *finishing*. Here they count, not only by *mains*, but also by *poses* and dozens. A dozen is composed of twelve *poses;* in rounding, the *pose* counts three *mains;* in finishing, only three half *mains*. In rounding, then, a dozen takes about half an hour; in finishing, twenty minutes; and as from four to six dozens of the first, and from two to four dozens of the second are required, a mould has to be beaten for nearly three hours. The workman himself settles the number of dozens that should be distributed over his mould, according to the quality of the gold and the speed of his labour; but he invariably composes his dozens equally, and keeps an exact account of the number of *poses* that he has struck. To verify and remember those he employs a little bit of wood, pierced with twelve holes, and fixed on to the casing of his store block, and after every *pose* he moves a peg from hole to hole until the twelfth is reached. Whenever a *pose* is marked the beater draws his tool from its sheaf, and with the greatest care and attention performs an operation which as much as the mallet blows hastens the

COOLING THE TOOLS.

speed of the labour. This operation, which is to the mould what the change of parts is to the smaller tools, consists in slipping the leaves of the mould one above the other. The workman judges what rotation is sufficient to keep the gold separate from the goldbeaters' skin, to which otherwise it would eventually blend in an incrustated state. The *handling*, which renders the mould softer and more flexible, spreads the heat out equally in all directions, which, without this, would be always concentrated in the middle. To carry out this operation, the workman takes the mould in his left hand, with the thumb above, and the fingers stretched straight out below; the right hand is next put into the same position. The workman then, without squeezing the mould, gives the corner of the tool placed before him three distinct movements, which smooth down the leaves or sheets of goldbeaters' skin; and he does the same thing to the three other corners. These four movements are called the turns of handling. After these four turns the ordinary work again commences, but they are careful first to turn the mould. They give twelve turns to each *pose* of the rounding, sixteen turns when under the heavy mallet, and twenty turns in completing the finishing. The rounding is made with a small and very round mallet, so as to force the bulk of the gold from the middle towards the borders during the first dozen; the other dozen ought to be continued so as still to spread the gold towards the borders, while their force is directed towards those parts, care being taken to avoid rendering the extremities of the leaves thinner than the rest. At the end of every dozen it is necessary to open the tool, and examine if the blows from the mallet have been well distributed; and this is proved by the nature of the impress left upon the gold by the beating. The rounding is finished when the gold quarter, put in originally at about 4 or 5 centimetres squared, has attained 9 or 10 centimetres; then the heavy mallet destined for finishing is employed, half *mains* only are given instead of whole *mains*, and the blows are now struck towards that edge which for the moment is nearest to the workman.

In the first dozen the beater strives to spread out his leaf as much as possible, without rendering the edges too thin; in the

final dozen, on the contrary, he should beat the edges, but still without hammering them into toothed fringes. As the beating acts upon the metal not by pressure only, but also by the heat set at liberty by the percussion, it is essential to be most careful in regulating the caloric, and this is one of the greatest difficulties to be encountered in finishing. During the last *poses*, the *handling* should be managed with the utmost attention, for the leaf in question by this time has become thinner and thinner, and consequently less able to offer any resistance. To maintain the heat, and at the same time not allow the gold to cool, a vast address and agility are necessary in sheathing and unsheathing the tool, in not precipitating the mallet blows, and at the same time in keeping the beating well regulated. One of the precautions most useful to the proper conduct of the work is that of never lifting the mallet above the eye, or lower than the shoulder; if it is higher, the shock is too great, and the time taken in descending is too long; if it is lower, the work is precipitated. The mallet blow ought to be given very straight; should it fall falsely it would cut in two two or three hundred leaves of the mould, and sometimes the entire tool. A mould ready for use being worth some 300 francs, we can see what a serious loss might be caused by a single mistake; and that would be only half the evil, if for 300 francs the manufacturer could be certain of procuring another of the same good quality as his own. The solicitude of the principals of the Favrel firm for their tools now in use is such that they lock them up every evening in a safe, placed in such a position that it can be thrown out into the street at the first indications of fire. The care bestowed upon the tools is one of the causes of the prosperity of the factory, because it insures perfect execution in all they turn out.

When the mould is considered to have done its duty, it is carried back to the office, where it is given to a work-girl, who empties it.

The metal in leaves is placed in little books, a collection of twenty-five sheets of red paper, the size of which varies from 85 to 94 millimetres square. To empty the mould the girl fixes it at an angle upon her cushion by means of her sliding-tongs, and places the open book in front of it; she then raises the first leaf of the goldbeaters' skin, and with her pincers takes up the first gold leaf, which she deposits upon the cushion, where she trims it with a little reed, and then places the outside innermost in the book. When she has filled her book with leaves extracted from the mould, she places them one above the other upon little boards termed *ais;* she then trims the other three sides of the gold leaves, cutting away all that protrudes beyond the boards, and rubs into a pellet all the fragments of the faulty leaves discovered in emptying the tools, and to this is added the fragments she has just pared away; next she bears to the office the books now full, the tool now empty, and the pellet of metal. The full books are carefully inspected, so as to prevent any faulty leaves being delivered to the buyers. Then the little books are fastened together in bundles of twenty each, comprising altogether 500 leaves of gold, a number long recognized in the wholesale trade.

These books are not by any means one of the least troubles in the industry of leaf gold—an industry where the slightest details are important, and where the neglect of a precaution, insignificant in appearance, might cause very heavy losses. These books were formerly manufactured by the gold merchants themselves; at present they are made by special paper makers, who are obliged to exert a most scrupulous accuracy so as not to deviate from the type adopted by the trade. One or two millimetres over much, repeated on the four sides of a thousand gold leaves, would constitute a very considerable loss; thus MM. Goguel and Co. attach a just importance to the absolute invariability of their types. These little books are made of "Joseph" paper, on which is spread a kind of very fine powder termed *bol*, composed of red ochre and a little brown.

It is not in the state of leaves only that gold is required by customers. It is employed, too, in powder prepared on a glass grinder in a mucilage of gum or honey, and pulverized with a large glass wheel. After being washed, this powder is dried, pulverized anew, and passed through a silk sieve, then preserved either in bottles or in the interior of shells, in which it is deposited while still in the liquid state. It is the same with silver and bronze powder, although the latter are rarely put into shells. Gold and platinum, destined for the dentist, and which consequently require an extreme suppleness, are formed into sheets by being beaten in the *cauchers*, and are annealed several times, and leaf by leaf, in the reverbatory furnace. For this purpose the metals should be absolutely pure. All the operations undergone by the gold in the course of manufacture necessitate the falling of a number of fragments which are carefully gathered up from the tables, the benches, and the stone blocks; but a notable quantity of gold falls through all the screens that ingenuity can devise; for this reason the least particles of dust are carefully collected and calcined in a cast-iron cylinder, the cinders resulting being treated by washing and mercury. MM. Goguel and Co. thus recover everything, even to the smallest particles of the gold ingots brought into their workshops in the Rue du Caire.[1] H. C.

ON THE EXTRACTION OF CANE SUGAR.

By M. Stammer.[2]

THE sugar-cane, *saccharum officinarum*, belongs to the family of Chinese grasses, originally coming from India and China. In warm countries, where it attains its normal development, it yields an abundant product of sugar. Arrived at a state of maturity, it possesses 90 per cent. of sugar juice, marking from 9 to 14 degrees on the Beaumé hydrometer, and containing from 12 to 20 per cent. of sugar.

There are several varieties of the cane, all, however, requiring a soil naturally rich, or a sufficient quantity of some manure exempt from an excess of mineral salts. The azote and phosphate manure seem, in most cases, to be best adapted to the cane plantations.

The canes are grown from cuttings, which are placed obliquely in little trenches. Each cutting produces several stalks, which take root downwards in the soil, and sprout upwards above the surface.

At the age of from twelve to fifteen months the canes attain the limit of their growth. The period of flowering commences, and some of them emit from their tops a long strong jet, without leaves or knots, and bearing a panicule of silky flowers differently coloured.

The maturity of the non-flowering canes is recognized by the yellow tinge that the stalks acquire.

The time of the maturity of the canes necessarily varies according to the latitude; besides, all the stalks of even the same plantation do not ripen at the same time. The period of harvest, then, must also vary, and the operations should take place in succession, according to the ripeness of the canes. The jet and the leaves are thrown aside, and they cut away the four or five top knots, not so rich as the others in sugar, and these serve for cuttings, food for cattle, or for fuel. They are especially careful to lay on one side all canes broken before the harvest, or nibbled by rats, either of which would introduce into the juice a fermentation hurtful to the sugar.

A hectare of canes, well cultivated, and which have not in any way suffered from atmospheric agents or the attacks of different animals, should yield from 40,000 to 50,000 kilogrammes of stalks.

The product of a hectare in sugar, varying according to the season and the nature of the soil, may, taking an average, be represented by the following numbers:—

Martinique	2,500	2,000 kilogs.
Guadeloupe	3,000	2,400 „
Réunion	5,000	4,000 „
Brazil	7,500	6,000 „

We will not here speak of the internal structure of the cane, but must refer the reader to the very interesting researches of M. Payen, given at full length in his "*Précis de Chimie Industrielle*," vol. ii. p. 385, &c.

The Composition of the Cane.

An analysis of fresh cane, made at Guadeloupe by M. Dupois, gives for each hundred parts:—

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[1] One grain of gold can be made to cover 56¾ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows that the leaf is $\frac{1}{282000}$ part of an inch thick. More than this, by computing the surface covered in silver-gilt wire, and the quantity of gold used, it is found to be only one-twelfth that of the gold leaf, or $\frac{1}{3384000}$ part of an inch thick; yet so perfect is it still, that no cracks can be discovered by the most powerful miscroscope. H. C.

[2] Our article is translated from the "*Annales du Génie Civil.*" Some two years back M. Stammer published a complete treatise on the manufacture of sugar. The whole edition was rapidly exhausted, and last January a new edition appeared, with the addition of a supplement, treating of the manufacture of cane sugar. From this we extract an interesting chapter. M. Stammer's work actually forms a large volume of 625 pages and 126 illustrations, and is published by Lacroix, 54, Rue des Saints-Pères, Paris, price 20 francs. This first supplement is sold separately at 6 francs.

Water	72·0
Sugar	17·8
Cellulose	9·8
Salts	0·4
	100·0

According to the more recent researches made by M. Casaseca, the sugar of the Creole cane at Cuba is composed per hundred parts of :—

Water	77·8
Sugar and other soluble substances	16·2
Woody fibre	6·0
	100·0

Taking into consideration only the sugar and water, and grouping the other substances around two distinct categories, according to their mineral and vegetable nature, M. Icery, in his "*Recherches sur le Jus de la Canne-à-sucre*" (a paper of fifty-three pages, read before the Chamber of Agriculture at Paris on the 16th March, 1865), formulates the average composition of cane juice per hundred parts at the Mauritius as follows :—

Water	81·00
Sugar	18·36
Mineral salts	0·29
Organic matter	0·35
	100·00

The same author has in a synoptical table preserved the results furnished by seventy-eight different analyses, executed with every possible condition of exactitude. We hereafter quote an extract from this table, remarking that by this means we are able to take into account the variations and changes which the different substances undergo according to the age of the cane, the period at which it has been experimented on, and the part of the plant examined. We shall also find in this table sufficient indications upon the relative richness in sugar of different kinds of cane, and the difference in the quality of the sugar of the same canes when subjected to pressures, stronger or weaker :—

Number in order of Original Table.	Dates.	Species.	Age in Months.	Reaction. a. = acid ; p. a. = slightly acid ; t. a. = very acid.	Temperature Centigrade.	Areometric Degrees.	Densiy.	Weight of Albuminoits Matter.	Weight of Ash.	Indications furnished by the Optic Saccrometer. Direct Notation.	Indications furnished by the Optic Saccrometer. Equivalent quantity of Sugar per Litre of Juice.	Indications furnished by Chemical Analysis. Absolute quantity of Sugar.	Indications furnished by Chemical Analysis. Quantity of Crystallizable Sugar.	Indications furnished by Chemical Analysis. Quantity of Uncrystallizable Sugar.	Notes.
1	April, 1864	Virgin Bellouguet	12	p. a.	25°	9·1	1·068	0·0054	—	85·8	140	13	—	—	Body of the cane
2	Id.	Id.	—	Id.	—	5	1·036	0·0066	—	31·9	62	7	5	2	Head of the cane
3	July, 1864	Virgin Bamboo	18	Id.	—	9	1·067	0·0042	—	99·3	162	16			
15	Augt. 1864	Id.	18	Id.	—	9·5	1·072	0·0056	—	108·1	176	16·5			
20	Id.	Mixed	6	Id.	—	5·8	1·043	0·0055	0·0030	50·6	82	10·5	8	2·5	
21	Id.	Virgin Bamboo	14	Id.	—	9·7	1·072	0·0048	0·0036	105·5	172·49	17	16·7	0·3	
26	Sept. 1864	Mixed	15	Id.	—	9·4	1·070	0·0037	0·0032	107·8	176·25	17	16·76	0·24	
27	Id.	Id.	17	a.	—	8·4	1·063	0·0029	0·0018	84·7	138	14	12·4	1·6	
39	Octo. 1864	Crushed Bamboo	13	p. a.	—	4·2	1·031	0·0071	0·0048	17·6	28	4·7	3·4	1·3	Body of the cane } In the same plantation.
40	Id.	Id.	—	t. a.	—	9·8	1·071	0·0037	0·0044	114·9	188	17·5	17·3	0·2	Head Id. } In the same plantation.
41	Id.	Id.	3	p. a.	—	5·5	1·040	0·0043	0·0024	34·4	56	7·5	5·1	2·4	Top Id. } In the same plantation.
46	Id.	Id.	15	Id.	—	10·9	1·083	0·0019	0·0021	130·9	214	49·7	—	—	1st pressure } Same cane
47	Id.	Virgin Diard	—	Id.	—	10·6	1·079	0·0027	0·0023	125·4	204·5	18·9	—	—	2nd ,, } Same cane
60	Nov. 1864	Crushed Otahaiti	14	p. a.	—	11·4	1·086	0·0023	0·0031	139·7	228·4	21			
61	Id.	Virgin Bellouguet	15	Id.	—	11	1·083	0·0045	0·0025	130·9	210	19·7			
62	Id.	Crushed Mixed	13	Id.	—	10·2	1·073	0·0038	—	120·4	196	18·2	17·9	0·3	Large and ripe } Same cane
63	Id.	Id.	2	Id.	—	—	—	—	—	11	18	3·8	2·5	1·3	Newly crushed } Same cane
64	Id.	Crushed Guingham	13	Id.	—	5·2	1·037	0·0068	—	40	65·4	6·4	5·2	1·2	Juice from the head } Same cane
65	Id.	Id.	—	Id.	—	6·6	—	—	—	58	94·8	10·8	9·4	1·4	
66	Id.	Bellouguet, 2nd crushing	—	t. a.	—	11·6	1·087	0·0052	0·0032	135·3	221·2	21·5	21·0	0·5	Id. Id.
67	Id.	Id.	—	p. a.	—	11·2	1·084	0·0053	0·0041	133·1	217·6	20·0			
68	Id.	Guingham	—	Id.	—	11·6	1·087	0·0043	0·0033	138·6	226·6	20·9			
69	Id.	Mixed	2	Id.	—	4	—	—	—	18·1	29·5	6·8	4·2	2·6	Recent sprouts
75	Dec. 1864	Virgin Bamboo	4	Id.	—	8·4	1·063	—	—	91·6	150	14·5	14	0·5	After heavy rains
76	Jan. 1864	Bellouguet, 2nd crushing	5	t. a.	27°	10·7	—	—	—	126	206	19			
78	Jan. 1865	Crushed Bellouguet	4	Id.	25°	8·5	1·064	—	—	91·3	148·7	15	13·7	1·3	After heavy rains.

M. Payen has made researches upon the composition of the juice at different periods of the development of the cane. The following are the results of this labour, and are drawn from the book quoted above :—

OTAHAITI CANE AT ONE-THIRD OF ITS DEVELOPMENT.

Water	79·70
Sugar	9·06
Cellulose and woody fibre	7·03
Albumen and three other azote substances	1·17
Starch, and colouring matter in green, yellow, brown, and red	1·09
Fatty and aromatic matters, hygroscopic substances, essential oils, salts, silica, &c.	1·95
	100·00

OTAHAITI CANE IN A STATE OF MATURITY.

Water	71·04
Sugar	18·00
Cellulose woody fibre, pectic acid	9·56
Albumen and three other azote substances	0·55
Starch, and colouring matter in yellow, brown, and red, fatty matters, resins, essential oils, and aromatic matter	0·37
Insoluble salts	0·12
Soluble ditto	0·16
(Phosphate of lime, magnesia, alumina, sulphate and protoxalate of lime, acetates, malates of lime, potash and soda, sulphate of potash, chlorite of potassium, and chlorhydrate)	
Silica	0·20
	100·00

The quantity of mineral salts in the juice of the cane is estimated by M. Icery, after very many analyses, at 29 per 1,000 of the liquid. The saline matter is found in larger proportions in the head of the cane than in any other parts.

The following analysis may be taken as giving the average proportions in which the substances are found which it is most important to determine :—

Potash and soda	18·83
Lime	8·34
Oxide of iron	1·99
Silica	11·48
Alumina, magnesia, acids in combination with bases	59·36
	100·00

We owe to the same author some very interesting researches upon the general nature of the juices of the cane, and upon the modifications which it undergoes during the work of extraction at the island of Mauritius. We have just quoted some few

passages of this work which deserve the particular attention of all manufacturers, and we regret that we are not able to give a more complete analysis.

Still, this is how the author expresses himself upon the results to be drawn from his chemical and microscopical studies :—

Resuming our facts, the juice of the cane, filtered through a cloth and then left quiet, is a liquid always more or less milky, and of a slightly yellow-greenish tint, more or less pronounced in proportion to the ripeness of the cane and of its deeper colour. In a normal condition, after deducting all the *débris* which are accidental, and which might be altogether isolated, it forms in two portions ; one portion solidly granular, and the other portion a liquid holding in dissolution a certain number of organic and mineral substances. The solid portion is constituted of globules or bodies organized in suspension, through the whole of the liquid, and which differ essentially from the other principal vegetables contained in the juice of the cane. These globules which during life possess undoubtedly special physiological qualities, are, of all the substances which the cane includes, those which possess to the highest degree the power of provoking alcoholic fermentation. Their action seems to commence with the emission of the cane juice on the outside, and it always becomes more manifest at the end of two or three hours, by a higher temperature at 20° centigrade. Consequently the subtraction of these globules retards the fermentation for a whole day, and when at the same time the albuminous substances are eliminated, the cane juice escapes all appreciable alteration for the period of two whole days.

It is sufficient to hasten the boiling of the cane juice which has just been extracted, and shortly after to pass it through a filter, to obtain a perfectly limpid liquid, which may be kept for a long time without any alteration.

On one side the eminently fermentable property of the cane juice under the influence of the globules and of the albuminous matter coagulable by heat, and on the other the possibility of eliminating these bodies at the same time as all the organic *débris*, by means of a boiling, quickly done in itself, and rapidly followed up by a filtration made so as to obtain a limpid liquid, are facts which it is sufficient to put forth in order to command an immediate comprehension of their importance. They would undoubtedly pave the way to very satisfactory results if they formed the basis of a new process applied to the industry of sugar.

In the ordinary practice of manufactories, as they are to-day arranged, this process would have three distinct advantages :—

1stly. In avoiding all immediate fermentation of the cane juice, and in the power of preserving it for at least a day, without the slightest trace of alteration.

2ndly. In diminishing the formation of incrystallizable sugar.

3rdly. In acting upon a limpid liquid, which being concentrated, preserves the whole of its transparency and original purity.

The globular and albuminous substances contributing essentially towards developing the acidity of the cane juice are the chief causes of the glucosic transformation of sugar. When we eliminate them it is easy to prove that this acidity increases only very feebly indeed through the action of heat, and always remains very inferior to what it would have been in the contrary case.

On the other hand, the means which we now employ to effect clarification and to cleanse the cane-juice both from the impurities natural to it and those produced during evaporation, are still powerless to completely fine this liquid, which, once in a state of syrup, contains an enormous quantity of particles, formed chiefly of very tenacious fragments of coagulated, albuminous, and granular substances.

Those particles, on account of their low specific weight, are with the greatest difficulty separated from the cleare after a long rest, and are still, for the most part, found mixed and scattered in the grains of the sugar obtained, the quality of which is thus always more or less changed. During the period of working they are often the starting point of the crystals which are just beginning to form, and to which they soon communicate a dull brown colour, and this being inherent to the constitution of the saccharine crystal, can only be taken off by careful washing in the water-wheels.

The presence of these corpuscules in any great quantity fully explains the difficulty that is experienced in obtaining a white and brilliant sugar, when the cleare introduced over soon into the refining machine has not had time to undergo a thorough cleansing in the open air. This, for instance, takes place in the triple vacuum pan into which the cane-juice is poured after the clarification, inevitably incomplete, to which it has been actually submitted.

The process which might be based upon the details which we have just explained could be easily adapted to all manufactories ; but there would be a powerful advantage granted to the three-fold machine, which, from the causes explained here, would furnish a sugar of a first-rate quality, in all the ordinary conditions of the manufacture which the colonial sugar industry is compelled to maintain. The application of this process would require nothing more than simple filters in the form of bags or punts, fitted with a series of metallic strainers, supported by moveable frames, and terminated by a thin sieve wrapped in one or two folds of flannel. The cane-juice issuing from the mill would at once receive the quantity of lime required for the quality of the sugar to be made, and could be rapidly brought up to a boiling temperature, and then be immediately poured into filters placed so as to allow a prompt and thorough filtration.

Basing his facts upon the analyses of cane-juice, which he has carried out for nearly two years, and which almost approach the number of a hundred, M. Icery has formulated the following table, in which, after the areometric degree (Beaumé) we find the quantity of crystallizable sugar in one litre of cane-juice, that is to say, in 1,000 grammes of this liquid. In the fourth column we see the considerable difference produced by the presence in the cane-juice of substances other than sugar :—

The quantities of sugar for a determined volume and weight of cane-juice, corresponding to the principal divisions of the Beaumé aerometer, or hydrometer, directly furnished by a series of experiments at 25° centigrade.

Areometer.	Grammes of sugar for one litre of cane-juice.	Quantity of sugar in weight.	Differences resulting from the influence of substances other than sugar (chiefly from the incrystallizable sugar).
4°	28	0·026	0 049
5°	49	0·048	0·047
6°	78	0·074	0·040
6° 1/4	85	0·079	
6° 1/2	91	0·086	
6° 3/4	98	0·092	
70°	105	0·099	0·036
7° 1/4	111	0·105	
7° 1/2	118	0·111	
7° 3/4	124	0·117	
8°	131	0·123	0·032
8° 1/4	137	0·129	
8° 1 2	144	0·135	
8° 3/4	152	0·142	
9°	159	0·149	0·026
9° 1/4	165	0·155	
9° 1/2	172	0·161	
9° 3/4	180	0.167	
10°	188	0·174	0·021
10° 1/4	196	0·180	
10° 1/2	204	0·187	
10° 3/4	211	0·194	
11°	217	0.200	0·015
11° 1/4	226	0·206	
11° 1/2	230	0·211	
11° 3/4	237	0·216	
12°	244	0·227	0·013

As to the nature and the quantity of saccharine matter which the cane contains, we quote the following results, to which the author has been led in consequence of his numerous experiments :—

Firstly. When the cane, whatever may be the species to which it belongs and the soil upon which it has been developed, has arrived at a regular vegetation, that is to say, at the period when it ceases to grow and when its different constituent parts suffer neither loss nor gain, a period easily enough recognized by the planter, it almost invariably contains prismatic crystallizable sugar in the whole of that portion known as the body of the cane, which extends from the first knots of the roots to those situated immediately below the green leaves which almost touch the bud or blossom of the plant. The quantity of interverted or other sugar, which the cane then yields, is invariably very small, rarely surpassing 4,000ths of the weight of the cane-juice or 1-50th of that of the prismatic sugar. Acting under the most favourable circumstances they ordinarily find only 1-95th.

This minimum quantity of crystallizable sugar is variable, but nevertheless it is constant when the examination extends over the juice drawn from the whole body of the saccharine plant. It increases in a very perceptible manner in the measure that the

juice is extracted from the joints between the knots at the upper extremity; and, starting from this point, it diminishes until the middle of the cane is approached, where it generally remains inappreciable.

Secondly. If, instead of examining the body of the cane, we experimented upon that portion still wrapped up in green leaves, and submitted to the direct action of the sun's rays, we find in the juice extracted from it a considerable quantity of incrystallizable sugar, which might be, on an average, reckoned for ripe canes at one-sixth of the weight of crystallizable sugar, and for canes not yet arrived at their full development at one-third of the same weight. This optical analysis leads to results directly opposed to those of chemistry, and, what is well worthy of all attention and calculated to provoke new researches, these results are not always identical with the same quantity of sugar as revealed by the processes of chemistry. In certain circumstances then, depending on the age of the plant and the activity of the vegetation, perturbations are produced which can only be explained by the notable differences in the rotatory power of the incrystallizable sugar which exists in the juice of that portion of the cane. The sugar liquid always deviates to the right of the plane of polarization, but after inversion the rotation to the left is rarely in accordance with the total quantity of interverted sugar which this liquid contains, and it may be generally expressed by a figure very much lower than that which should have obtained.

The proportion of incrystallizable sugar in the head or summit of the cane, in the same way as in the body, increases exactly as we test a part more and more distant from the inferior portion, and the part that contains the greatest quantity is that which the tubes of the green leaves have completely sheltered from the approach of the light. This portion of the head of the cane, the bark or peel of which is widely spread, and not coloured, remains, as long as it escapes the action of the sun, the principal seat of the liquid sugar which the plant contains; but as soon as the leaves are dried up and the cane is exposed, it commences to take exteriorly a colour more and more pronounced, and at the same time the incrystallizable sugar begins, little by little, to disappear from these tissues, to give place to sugar properly so-called, or crystallizable sugar. This remarkable transformation can be very easily observed in similar canes, which have undergone the same culture, by analyzing at an interval of a few days the portions which by reason of the leaves are more or less dissimilar, and then the corresponding portions of other canes as their leaves fall off, and they are coloured under the influence of the light.

Thirdly. The age of the cane appears to be only an indirect cause of the phenomenon which we have just noted.

If we place the young canes in the ordinary positions of air, light, and growth, and wait till they attain their full development, we can gather nothing special as to their relative quantities of liquid sugar and incrystallizable sugar contained in the body or in the head. In a general way, however, we might say that the younger the cane is the more incrystallizable sugar it contains; but it is only to some fault in the action of the solar rays upon the bark, tightly clasped by the stems of the leaves, that we should attribute any extraordinary proportion of interverted sugar.

Fourthly. A growth too active or too retarded does, in this respect, exert an influence as great as, and not less appreciable, than that of the light, about which we have just spoken. Many canes, which on reaching maturity contain no trace of levulose at all, are speedily charged with a large quantity of this substance, when once they burst into full vegetation, and this condition is kept up as long as their broad green leaves are being rapidly renewed and the buds sprout forth; and as long as the plant preserves the appearance peculiar to it, while it still continues to grow. We can then recognize that its juice is richly supplied with incrystallizable sugar, chiefly in the tissues last formed, and, consequently, less exposed to the action of light. In damp localities, when the canes never ripen, and are constantly in full sap, the incrystallizable sugar always exists in every portion of the plant, and sometimes in a very considerable quantity.

When we investigate the proportion in which these two kinds of sugar are presented at different phases of vegetation, we ascertain that it is always in canes which have ripened most rapidly that the greatest quantity of levulose exists, and for this reason the canes termed *folles* or *babas*, which in two months attain a height of 5 ft. and a transverse diameter of from 3 to 4 in. at their base, are those which should be placed in the first rank.

The following analysis of one of these canes displays in a very forcible manner the relative quantity of incrystallizable sugar:—

Sugar	Crystallizable . . .	3·6
	Incrystallizable . . .	2·4
Water		94·0
		100·0

It is important to remark, that these *folles* canes, springing rapidly in the midst of large plantations, which protect them, generally have a tender and non-coloured bark.

The extraction of the juice is obtained by means of cylindrical presses. It is only quite recently that they have successfully introduced the process of maceration, known as *diffusion*, which was borrowed from the beet-root industries.

The larger of the old mills, which indeed are still used in many colonial factories to crush the canes and extract the juice, consist of huge stone rollers or cylinders, with cogs of the same material. In other places they substitute presses with three vertical rollers of cast iron, and these again have been replaced in the newest buildings by a perfected machine, which, borrowing from M. Payen's volume, we herewith describe.

Formerly the motive power was exclusively furnished by either a water-course, by wind, or by beasts of burthen; since then the use of steam has been introduced, and there is now a great tendency to its becoming more and more common.

The most powerful presses yet introduced into the colonies yield from 50 to 55, from 60 to 65, from 70 to 75 kilogrammes of the quantity of juice extracted from 100 kilogrammes of cane. These presses are formed of three cross rollers of cast-iron, placed horizontally in a strong and solid building.

The rollers are brought nearer and nearer to each by the force of pressure. One of them is set in motion by a large wheel fitted with a pinion, and transmits the movement to the others by three cog-wheels, mounted on the axles of the three rollers. The canes are carried by an endless cloth on to a platform, then passed between the two first cylinders, where they are flattened and pressed. Next they fall down a slight metal incline, between the second roller and the third, and these are so brought together as to make the pressure as gradual and complete as possible. The rollers should be worked slowly so as to give the juice time to flow. To-day, thanks to the perfection bestowed by Messrs. Cail and Co. in the construction of their rolling presses, they obtain (notably at Cuba and Réunion), 70 and sometimes as much as 72 per cent. from the canes.

These happy results are due to the great solidity of the presses and mountings, and also to the carefully calculated slowness of the rotation of the cylinders. For instance, if one set of presses accomplished one revolution round their axis in two minutes, instead of one revolution per minute, their yield of juice would be lessened in the same proportion as if their dimensions had not at all been increased. Messrs. Cail and Co. built this powerful machine with cylinders as much as a metre in diameter, and 2 m. 10 in length; these produced from 300,000 to 400,000 litres of juice per day, and required a force of 90 horse-power, but the means of heating became insufficient on account of the more thorough exhaustion of the sugar in the canes. In short, when they extract only 50 per cent. of the juice, the *trash* or *cane trash* (the residue after squeezing) retains for 500 kilogrammes of canes 50 kilogrammes of woody-fibre, and 55 kilogrammes of sugar, representing 20 kilogrammes of a combustible analogous to wood. On the other hand, if the machine is fitted with every possible improvement, and is able to extract 70 per cent. of juice, there remain in the trash of 100 parts of cane, only 4 of sugar, plus 10 of fibre, representing together not more than 14 of a combustible analogous to fuel wood; so that in this case we have two-fifths, or ·4 more juice to evaporate, and ·3 less fuel. Fortunately the serpentine machines, and the three-fold machines, have been able to satisfy this new condition.

M. Payen has pointed out a new arrangement which augments the outcome of the cane presses. This consists in heating the interior of the rollers with steam, as is done in the manufacture of paper. The cane heated during the pressure loses a portion of its elasticity, permits the juice to flow more freely, and, as it swells less after the crushing, reabsorbs less of the juice than when it is submitted to a cold pressure.

It sometimes happens that the knots of the canes become jammed one on the other, or that some hard foreign body enters between the rollers, and presents such a resistance as to cause the breakage of one of the parts essential to the mechanism of the mill. This accident would be extremely grave if the makers had not taken the precaution of constructing one of the pieces of the machine—the beam or arbor which transmits the motion to the pinion on the big wheel for example—much weaker than the others. Any sudden accidental effort, then, results in the fracture of this particular piece. As they can always keep several of these pieces in stock, long delays are avoided. Messrs. Cail and Co. employ a more useful arrangement still by placing one of the cog-wheel gearings in the form of a circle in the big wheel, so as to be very easily displaced. We can understand how a powerful effort would turn aside the circle of the gearing, and bring the press to a standstill. It can then be disconnected, the obstacle removed, and work resumed.

They could still further increase the outcome by employing

mills with five cylinders; the canes would then be submitted to four successive pressures; and, besides this, a portion of the juice could be extracted by throwing steam mixed with drops of water upon the canes before they reached the last pair of cylinders. These arrangements have been applied by M. Nillus and by MM. Dérosne and Cail. They did produce the desired effects, but the somewhat complicated nature of the presses led them to renounce the invention, until, at all events, the time when mechanical industry shall be more advanced in the colonies.

If it be advantageous for the planter to extract from the cane almost the total amount of the juice which it contains, he still should not press the extraction to the furthest extent; for the pressed canes or trash, the only fuel at hand in the greater number of the colonies, would be of little use in this respect, if they did not contain a certain amount of sugar. They should be careful, too, to avoid breaking the canes when they press them, for it is difficult to feed the fires with over-small fragments.

Extraction of Cane Sugar by Diffusion.

The process of *diffusion*, mentioned above, has been applied with great success to the extraction of the juice from the canes.

According to M. Karup, the diffusion gives 88 parts out of the 90 parts per cent. of juice that the cane contains. The chief condition of success consists in obtaining pieces as small as possible, which is done by cutting the cane obliquely at its several consecutive knots. Cutting machines for this work have been constructed by M. Jacquier.

The fragments of used cane are easily dried in the sun, and might be used, like the trash, for fuel, although the small quantity of sugar they contain renders them but of slight value.

We owe to M. Michin[1] many precise results of investigations upon the notable advantages presented by this extraction by diffusion at Aska, in the East Indies:—

1. The power necessary for the cutting of all the canes is less than that required for grinding and pressing.
2. The diffusion supplies a juice purer than that of the mills.
3. As the cane contains only a small quantity of pectine, the temperature of extraction can, without any inconvenience, be increased as high as 70° centigrade.
4. The diffusion supplies a quantity of juice one-fifth more than that obtained by aid of the mills.

Writing more recently, the same author has declared the results of his second campaign on diffusion. The results epitomized are these[2]:—

1. The quantity worked was 3,300 tons.
2. The average work in twenty-four hours was 70 tons.
3. Four or five cutters were employed.
4. They obtained 85 per cent. of juice.
5. They produced 13·33 per cent. of sugar in the first and second boiling.
6. The broken fragments of the canes were used as fuel.

The average composition of the canes worked was:—

Cane sugar	13·74
Glucose	1·16
Foreign substances . . .	0·64
Total	15·54

That is, 15·54 parts for 100 parts of cane, equivalent to 11·94 per cent. of sugar in its subsequent crystallized form. The residue showed from ·13 to ·49 of sugar to 100 parts of cane, corresponding to from ·76 to 2·35 of juice. The waste water displayed from ·05 to ·18 per cent. of sugar, so that the total that had been lost in the residue was from 1·3 to 4·34 per cent. of juice.

The apprehensions founded upon the fermentation and easy decomposition of the juices under the action of the climate were not realized; they were always able to work without having to add lime during extraction, and even the waste waters were advantageously employed in the condensation of the vapours during the concentration of the juices and syrups.

The advantages, then, of diffusion, as applied to the working of the canes are—an increase in the outcome of juice of 20 to 25 per cent.; a greater purity in the product itself, and a reduction in the cost of buildings and labour.

Still, it is true that the juices from the diffusion contain from 10 to 15 per cent. more water than those from the mills.

The juice obtained from the cane presses is poured into a large reservoir, where it remains for the space of an hour before passing into the boilers to be clarified and dried. During this period of repose the woody *débris*, &c., are eliminated; but at the same time contact with the air develops baneful fermentations. It is, then, essential to diminish the time of rest as much as possible.

The boilers, to the number of five, form what they call a set. The first, the *large boiler*, which is the most distant of all from the fire, is used for the clarification, which is performed with from 2 to 3 per cent. of lime. A thick scum forms, which, at the moment of boiling, opens, to give passage to a limpid and colourless liquid. The lime neutralizes the malic and other acids, and forms, with the albumen, &c., a large precipitate, appearing under the guise of a thick layer of green on the surface. A larger quantity of lime than this should not be employed, on account of the action of this substance upon the glucose which is found in greater or lesser quantities in all the cane juices.

They skim off the scum and pass the juice, with the aid of a ladle, into the second boiler; then the evaporation commences, during which other scums are formed, which in their turn are taken off and thrown into the clarifying boiler. From the second boiler the syrup is turned into what is termed in English the "third boiler," but in French the *flambeau*, because in that they see, from the colour and limpidity of the liquid, whether the clarification is completed, or if a little more lime-water should still be added. The syrup then passes into a fourth boiler, called the *syrup*, where the concentration is continued. Finally, it is poured in the fifth, or "battery" boiler, where the process is completed.

In principle, each boiler should have its own fire; consequently, the whole set, by way of economizing fuel, are established upon the same fire.

The boilers, originally made of cast-iron, and hemispherical in shape, are now manufactured of copper, with rectangular borders. The operations are facilitated by sets, which possess on the edge of the boilers a "platform:" drains or channels through which the liquid can be carried from one to the other. Thus the loss of syrup by accidental spilling is altogether avoided, and by this arrangement, too, the skimming and moving are executed with the greatest facility.

These were (and such in most neighbourhoods still are) the extremely defective means of extraction before the employment of the perfected mills; 1,000 kilogrammes of cane, containing as a *minimum* average 160 to 190 kilogrammes of sugar, never formerly yielded more than from 55 to 65 kilogrammes. The results of these operations may, according to M. Payen, be thus represented:—

Sugar obtained	55 to 65
Sugar absorbed or changed into glucose, and the incrystallizable sugar in the molasses . . .	25 to 20
Sugar left in the trash . . .	80 to 75
	160 160

The enormous loss of from 95 to 105 upon 160, or an average loss of 56 per cent., should be attributed to a pressure too feeble, to an over prolonged duration of time for the operation, and to the employment of some fuel that burns a portion of the sugar and produces a large quantity of molasses.

In order to diminish these inconveniences numerous improvements were brought to bear upon the machines. The old sets were replaced by bascule boilers placed on rows of steps, and heated by one single fire; the flame, moreover, was passed below the grand boiler through a system of vertical tubes, surrounded with water, so as to better utilize the heat, &c.

The last evaporation of the boiling always offers serious difficulties when it is effected over the naked fire. The old battery, then, has been replaced by boilers of different forms, but which generally consist of a demi-cylinder with a double bottom for the circulation of the steam. A cross axle, fitted with tubes the discs of which are also crossed, is turned about in the hollow of the boiler, so as to constantly agitate the mass to be evaporated, which it warms at the same time by means of the steam circulating in the interior. Boilers of this kind have been constructed by M. Wetzel and M. Bour.

The presence of saline matters in the juice, and the action of heat and air, are the causes of the transformation of a part of the sugar into incrystallizable sugar. The losses which thus resulted, the general difficulties to be always encountered in the colonies, the necessity of most carefully watching all the operations, led several people to believe that the sugar should be evaporated after clarification as rapidly as possible, and reduced to a solid mass, which could be submitted to all the purifying processes when and where it might seem good.

Starting from these ideas, M. Fryer constructed the "concretor," an apparatus which in a short time converts the juice

[1] "*Jahresbericht*," vii. p. 300.
[2] "*Produce Market Review*," 4 July, 1868.

into a concrete matter containing sugar and molasses. The problem has been resolved by evaporating, even to dryness, large masses of the juice in the shortest possible time without overpassing a determined degree of heat. No derangement or serious accident has to be dreaded in respect to the apparatus itself, and no one of its parts requires a construction either difficult or complicated. It is economical both as regards fuel and manual labour. When in full swing the juice flows constantly in at one of the extremities, while at the other, it goes out converted into the solid mass termed concrete. The flowing of the juice only occupies fifteen minutes, and during that interval not the slightest portion of the sugar is interverted. It works at the rate of five casks per ten hours. We borrow the following description of the "concretor" from the "*Journal des Fabricants de Sucre*":—

The apparatus consists of three principal parts: the end-plane, or canal, the cylinder, and the drum.

The end-plane is placed as near as possible to the cane mills, and receives the juice directly from the rollers. It is made of cast-iron, and is 25 ft. long by 6 ft. broad, with a depth of 6 in. It is crossed by bulkheads starting from each side alternately, and leaving an interval of space on the opposite side. This end-plane is not cast in one single piece, but is composed of different parts fitted together one to the other, which can be unjointed and replaced with the greatest facility.

This end-plane is slightly inclined upon its axis, so that the juice received in the anterior part flows in a continuous stream of a thickness of only half an inch from compartment to compartment, until it reaches the end of the instrument. The total length of the flow is about 110 metres.

Under the end-plane we find the furnace, and its flame spreads along the whole bottom, licking it in an incessant manner if the fire is well kept up and never interrupted. The time taken by the juice in traversing all the compartments is about five minutes, and in this short period five-sixths of the evaporation are accomplished and the juice begins to change into syrup.

Quitting the end-plane, the concentrated juice passes at once into the second portion of the machine, that is, the cylinder. This is made of copper, and is 20 ft. long by 3½ ft. in diameter; it is set in motion at the rate of eight revolutions a minute by a little engine appropriated to this purpose. The cylinder is partially open at its extremities, a narrow ring with a concentric rim being adapted there to retain the syrup in the lower part, and from the motion of the machine the syrup is passed through this in little continuous driblets. The cylinder is warmed on the outside by the waste heat from the end-plane furnace, or by the vapour escaping from the juice, sometimes even by both at once; and in the inside by the injection of a jet of air warmed by the steam escaping from the little engine. Whatever may be the temperature acquired by this air, it is never high enough to burn the syrup, the heat being immediately absorbed by the vesicules of water raised by the force of the injection.

With the aid of a very ingenious arrangement, the liquor enters the cylinder in a continuous manner, and is as continuously drawn from it. If we consider that the entire surface of the cylinder is exposed to the action of a jet of warm air as well as to the heat applied on the outside, and that the surface of the syrup-bed represents more than 150 square feet, we cease to be surprised at the extreme rapidity of the drying.

After waiting for a few minutes in the cylinder, the juice now concentrated, and in a state of syrup, is freed from risk of fermentation, and may, without inconvenience, be stored in casks for exportation to Europe. But if it remains in the cylinder over long, a quantity of water is left in the sugar, useless at best, and likely to expose it to a risk of leakage. It then is necessary to submit the matter to a third operation, which is accomplished in that part of the apparatus termed the "drum."

The drum is a large iron cylinder, 4 ft. long by 4 ft. in diameter, also heated on the inside by the steam from the little engine. The syrup is distributed slowly throughout its whole surface. The drum has a motion of two revolutions a minute, and receives, like the cylinders, a jet of warm air, which completes the concentration and forms the concrete sugar. The sugar is then emptied out as it forms by a shovel adapted to the purpose. While it is still warm, and before it hardens, it can be moulded into blocks of any form; but no sooner has it cooled than it acquires a remarkable hardness. In this state it can be packed up and sent away in bags instead of casks.

As to the nature of the products of the "Fryer concretor," we can understand that it cannot be in any way like that of ordinary sugars, more or less freed from their molasses; the composition of the concrete is rather that of a clarified juice, a juice, that is to say, purified and freed from the greater portion of its water. For ampler information on this subject we must refer the reader to the analytical studies of M. Duhranfaut,[1] and to reports of a special commission upon the refining of a parcel of concrete sugar.[2]

The concrete requires nothing more than refining. The ordinary syrup coming from the boiler in a liquid state, has to be once more thrown into a reservoir; after being cooled to 45 or 50 degrees the partly crystallized mass is placed on huge strainers, the bottoms of which are perforated with holes, and the syrup drips through these.

In the ordinary way of working at present they pour the liquid, or "boiling," into large bags, where it is left to cool and crystallize for about twenty-four hours; after this lapse of time the granular mass is placed in moulds where the crystallization is completed. Finally, the drying is effected by means of tubs, in which the sugar is further purified by liquoring it with diluted syrup or with steam.[3]

The old factories made only one product; the improved refineries of to-day furnish two or three.

After having yielded the sugar, the juice still gives from 5 to 6 per cent. of molasses, which comes to from 1,000 to 2,000 kilogrammes per hectare of sugar-canes. The molasses is composed in the following manner:—

Saccharine matter	65
Water	32
Organic matter	3
	100

Modifications undergone by the Juice during Manufacture.

We again borrow from M. Icery's pamphlet some very interesting considerations on several of these modifications, based upon the results of numerous chemical experiments. The author lays special stress upon the notable differences displayed by the fermentation developed in the juice upon the different azote substances which this liquid naturally holds. "We know that sugar submitted to fermentation furnishes several products which are not always alike, and that the decompositions to which it then gives rise depend upon the ferment. The azote substances of the juice, which we have divided into three classes, and which we have distinguished by the names of granular matter, albuminous matter, and matter coagulable by alcohol, possess the property of provoking the fermentation of this liquid; but they do not all three act with the same energy, and one of them alone is apt to determine the alcoholic fermentation, properly so called, while the other two (albumen and matter coagulable by alcohol and not by heat) give birth at the same time to acid products, and are very much slower in their action. The granular matter, then, is the origin of the most active ferment which develops in the cane-juice at contact with the oxygen in the air, and, beyond that, it contributes in a more especial manner to the transformation of sugar into alcohol and into carbonic acid.

"We will not insist more, for the moment, upon these different specialities. We think, too, that we have sufficiently traced the important part that this substance plays in colonial industries, and that we have shown all the advantages that would result from its elimination from the cane-juice directly the juice comes from the mill. We have on this subject indicated a process which would incontestably render a great service to the sugar industry if it were put into practice by some skilful mechanician.

"The accumulation in the cleare and the syrups of the complex azote substance which we have before described [a complex organic substance, precipitable by alcohol and acetate of lead, very soluble in alkalis and acids, even in tannic acid] is a fact that has not up to the present time sufficiently arrested the attention of sugar planters, and which, nevertheless, deserves to be studied with a very special care.

"It is essential to remark that no agent employed hitherto in the colonial manufactories has had any action upon this substance, which escapes almost entirely, and concentrates itself more and more in the liquids in which the labour of our refiners is employed.

"We can obtain some idea of the proportion in which this matter increases in its concentration in the syrups, if we consult the last column of the table given elsewhere. We shall see that the figures representing it follow a rapid progression, and that they are from 6 to 7 per cent. higher for the third syrup than for the cleare at 22 degrees Beaumé.

"Examining the preceding column, we can in like way ascer-

[1] "*Journal des Fabricants de Sucre*," eighth year, No. 31.
[2] Id., ninth year, No. 51.
[3] See chapter 4, book iv., of the treatise under notice.

tain the growing progression that follows the quantities of saline matters proper to the different syrups. These two kinds of substances do not always suffice to explain the resistance that hinders the crystallization of syrups produced under certain circumstances.

"There certainly is one very active cause for this hindrance, and that is the presence of a smaller or greater quantity of glucose in the liquids undergoing manufacture. This glucose, or rather dextrose, or right-handed glucose, is a sad bar to the colonial industry, and the source of the chief difficulties against which the planter has incessantly to struggle.

"From the experiments made on this subject we may conclude that in the cane-juice generally worked there always exists some levulose (or left-handed glucose), and this is found in a proportion so much the higher as the canes worked are less ripe, or if they come from a wetter soil, or if they have been cut close up to the green leaves.

"The presence of right-handed glucose once admitted in the cane-juice, it is easy to understand the first difficulty that presents itself, and the impossibility, almost absolute, of efficaciously combating it. How, in brief, to avoid the very prejudicial action of the lime upon the levulose, which at boiling heat, and in contact with this alkali, gives birth to black glucosic products, the presence of which so thoroughly alters the colour of the juice, and indeed the quality of the sugar—how to obviate so real an inconvenience, and yet to arrest the great tendency that these juices exhibit to produce during boiling a considerable quantity of glucose.

"Alkaloiding with some liquid would doubtless put an end to this rapid transformation; but this alkaloiding would in itself have consequences graver than those against which we are endeavouring to combat.

"Lime, the utility of which is incontestable, but the importance of which people are disposed to exaggerate, cannot then be employed to excess without becoming the cause of one of the most baneful modifications the juice can undergo; it immediately results in the brown coloration of the syrup, and, as an ulterior consequence, in the production of a sugar coloured, moist and pasty.

"The part played by lime in the manufacture as it is carried on at present should be limited to neutralizing moderately, and little by little, the acidity of the juice. Employed in too small a quantity, this alkali does not offer a sufficient obstacle to prevent the glucosic transformation of crystallizable sugar under the influence of azote matter non-coagulable by heat, and the syrups would be strongly charged with levulose. Employed so as to cause a slight alkaline reaction in the liquid, the sugar from the juice would be scarcely left-hand glucose; but it would acquire a colour that would upon sale place it in a rank altogether inferior; and as the qualities and colours most sought after, and most remunerative, can be obtained only with the aid of a juice kept slightly acid, the attention of the manufacturer should be directed towards realizing these shades, while keeping the glucosic transformation as low as possible, that is to say, in not surpassing in a given example the degree of acidity proper to it.

"But it is above all after the separation of the scums that the acidity of the cane-juice should be most carefully watched, for then the temperature of the liquid rises rapidly, and the inversion of crystallizable sugar is the easiest. This acidity increases on account of the proportion of non-coagulated albuminous matters, and these are the indirect but active causes of the formation of glucose.

"To appreciate the different quantities of interverted sugar, or dextrose, produced, as much under the influence of the normal qualities of the juice employed as on account of the acidity, greater or lesser, of this liquid during working, we have made several analyses, the results of which are given in the two following tables."

(We, however, have condensed from these interesting analyses only those which concern the modifications proper to interverted sugar.)

"*First.* That two juices, coming the one from canes not ripe, although entirely developed, and the other from canes arrived at maturity, both worked under the same conditions, give rise to a glucosic transformation of crystallizable sugar, little active in the second, very energetic in the first, and that in such a proportion that the second syrup, resulting from the unripe canes, contains almost equal parts of prismatic sugar and levulose, that is to say, should be abandoned as useless; while even the third syrup, produced from the ripe canes, contains only 27 per cent. of levulose, and is ready, consequently, for a fresh boiling.

"*Second.* That the acidity kept in the cane, in the aim of obtaining certain qualities of sugar, is often pushed beyond the conditions to realize these qualities, and thus becomes a very appreciable cause of loss—the syrups not being profitably gathered when the quantity of levulose exceeds 37 per cent. of the total weight of the saccharine matter they contain."

Residue and Yield.

Molasses are distilled to produce rum or sold for consumption. The trash is utilized either as fuel (100 kilogrammes of trash being equal to 10 kilogrammes of coal), as manure, or as fodder.

Yield. We borrow from the "*Journal des Fabricants de Sucre*" (fourth year, number 50) a note upon the outcome of two factories in Martinique, of which one, fitted by the firm of Cail and Co., was supplied with every modern improvement (black filters, steam boilers heated interiorly, tubs, &c.), while in the other they worked without filters or strainers, and with Wetzel boilers and tubs.

The Cail factory received 8,841,334 kilogrammes of canes, which produced in sugar:—

1st boiling	. . .	557,703 kils.
2nd „	. . .	203,767 „
3rd „	. . .	74,272 „
Total	. .	835,742 „

The second factory received 3,861,205 kilogrammes of canes, which produced in sugar:—

1st boiling	. . .	266,418 kils.
2nd „	. . .	72,553 „
3rd „	. . .	31,043 „
Total	. .	370,014 „

The first had a residue of molasses, which was sold to a distillery, of 207,578 litres; the second a residue of 90,000 litres of molasses, which was also converted into rum.

The outcome, then, in the two factories was 9·5 kils. of sugar and 24 litres of molasses per 100 kils. of canes; but in quality the results were more lucrative in the first factory by a proportionable profit, over the other, of 50,144 francs.

Quantities of Crystallizable Sugar, of Interverted Sugar, and of Saline Substances contained in 1,000 grammes of Syrup at 25° Cent. and at 41° Beaumé.

(*The quality of the sugar manufactured being almost similar.*)

Name of the products.	Reaction of the syrup.	Quantity of incrystallizable sugar contained in the juice from which comes the analyzed syrup.	Total of sugar found.	Crystallizable sugar.	Interverted sugar.	Proportion in which crystallizable sugar and interverted sugar are found per cent. in total of sugar.		Saline matter.
						Crystallizable sugar.	Incrystallizable sugar.	
1st Syrup	Almost neuter	0·003	830	752	78	91	9	27
	Acid . .	0·004	813	597	216	73	27	40
	Almost neuter	0·012	718	544	174	76	24	
	Neuter .	0·009	741	592	149	80	20	
	Almost neuter	0·008	699	525	174	75	25	
2nd Syrup	Almost neuter		692	576	116	83	17	46
	Acid . .		741	499	242	67	33	50
3rd Syrup	Acid . .		506	296	210	58	42	
	Neuter .		629	483	140	77	23	60

H. C.

STREET PAVEMENTS AND HORSESHOES.

THE long-vexed question of what is the best description of roadway to put down in the streets of large towns seems as far as ever from a satisfactory solution. Something like five years back the Val de Travers Asphalt Company obtained a concession from the Corporation of London to put down their pavement in the Poultry. This, while not exactly the first trial of asphalt, practically was the first so far as the ability of horses to work over it in safety was concerned. Some time previously a score or so yards had been put down in Holborn, but the portion was too small to form a fair test as to its fitness for street pavement save as regarded its durability. A score or so of yards would show as well as a score of miles the endurance of the material, but could form no test of how horses

GEMS OF THE VIENNA EXHIBITION.—BRONZE VASE ENCRUSTED WITH SILVER. By Christofle.

could work over it in all the varying conditions of an English climate. Even the paving of the Poultry failed to make apparent the defects of the new pavement in this respect. The advantages were, however, made very apparent; the lull in the nerve-racking din made by the tide of traffic over the stone pavement was hailed as a relief, not only by foot passengers, but by the tradespeople and other inhabitants of the houses at either side the road. With the old stone pavement, however sultry the weather, no man of business occupying a front apartment dare open his window unless he wished to converse with his clients through a speaking trumpet and to get himself choked with dust. The fact that persons walking alongside the asphalt could converse and hear, and make themselves heard, without shouting and being shouted to, helped to the subsequent extensive introduction of asphalt pavement into the streets of London. This extensive introduction of such a sort of roadway lays bare one—happily the only one—defect of the system: it is found under particular conditions to be so slippery that even human beings, shod with a material so little slippery as leather, must needs exercise caution when walking on it; and human beings drag no load behind them, they have not to stop and start heavily-loaded vehicles every other minute. What, then, is the task we set those patient and valuable servants, our horses? We furnish their feet with plates of iron that speedily become as smooth as razor-blades; we shoe them, as it were, with skates, with, indeed, worse than skates, for skates, if used in one direction, offer powerful foothold, but horseshoes afford no resistance in any direction. The consequence of such a practice is patent to every person who ever walks in any thoroughfare paved with asphalt. Horses may be seen falling on every side, and what is at least quite as bad, getting many more falls in their struggles to regain their feet. This being the case, it can hardly be wondered at that such a meeting as that which lately took place at the Freemasons' Tavern, and attended, we learn, by something like a thousand persons, should be convened. At that meeting all or nearly all the leading horse-owning interest was represented, while many persons were present to represent the cause of humanity. The speakers were unanimous in denouncing the present state of affairs as regarded the asphalt. The proximate cause of the meeting was to deprecate the proposed introduction of the asphalt pavement in Oxford Street and Holborn. Omnibus proprietors, cab-owners and drivers, veterinary surgeons, all united in the one tale of cruelty and injury to horses from the falls and strains they suffered in their struggles over a pavement hard as flint and in particular states of the weather slippery as glass. Could asphalt be kept either perfectly dry or perfectly wet, it would make very fair foothold; this being impossible, it becomes a pressing question whether its many advantages, its freedom from noise and dust, the ease with which mud can be swept from it, and its slight resistance to the rolling of wheels, and also the trifling wear and tear to rolling stock, counterbalance its destructive influence on horse-flesh. On what may be called "greasy days," we think there is no room for hesitation, no person of the least humanity, no person himself a horse-owner, would return any but one answer, condemning such a pavement.

The meeting at the Freemasons' Tavern was convened to condemn asphalt; but while it must be admitted that its extensive introduction has perhaps been somewhat hasty, we must remark that little or nothing was said about the question of horseshoes, and nothing at all about the defects of the stone pavement superseded by the asphalt. Because horses fall and are injured on the asphalt, it must not be lost sight of that certain sorts of weather made the stone paving as slippery as ever the asphalt is, and that moreover the stones were worse things to fall on than the smooth asphalt. A horse coming on his knees of a frosty morning on an unequal piece of granite would, and we believe will always, suffer more injury than if he comes down on asphalt.

We are glad this meeting at the Freemasons' Tavern took place, because it shows that horse-owners, and the public, we believe, at large, are becoming alive to the evils of the present methods of working our street traffic. We would have been more glad, however, if all the speechifying had not been confined only to the road. As a matter of fact, the asphalt is nearly the best road we could have if we would but learn to shoe our horses more in accordance with common sense. Horseshoes show no more change in their construction than does the potter's wheel, there being, however, this material difference between the two, that while the latter has remained as it is simply because it is difficult to see how it could be made to do its work more admirably than it does, just the reverse must be said of the former, for it is hard to conceive anything more utterly unfitted for its purpose. The horseshoe was invented when horses were principally used for equestrian purposes—to carry men in battle or the chase, and in either case a horse had neither a load to drag behind him nor a hard paved road to travel over. Every one knows the sort of roads, if they deserve such a term, which our forefathers had, before the days of Macadam; now macadamized roads are useless in large towns, so we have come to granite and asphalt; the road-maker has kept pace with the times, while the farrier and the horse-owner show no advance beyond what was done centuries ago; yet such is the injustice of human nature, the horse-owner saddles the road engineer with the faults that of right he himself ought to share with the farrier. It appears not a little remarkable that at the Freemasons' Tavern, the other day, no farrier spoke; that honourable guild, it might be thought, would have had a word to say, yet it said no word. The present conditions under which horses are worked is essentially a defective one. The proper philosophical sequence of arrangement is that the road should suit the wheel carriage in being as smooth and even as possible, and also as durable; the horse's feet, then, should be made to suit the road, they should be so shod that the shoes would present a rough face to the road. The road is made good, the wheel-carriage is good, but the horseshoe is antiquated. We shoe our draught horses as we shoe our hunters, the latter having no load to drag and having soft, springy turf or stubble to gallop over; the former we put on a road made purposely hard and smooth, to offer the least possible resistance to the wheels, and tie him to a heavy load, and when, in his efforts to do his work, he falls, the horse-owner, instead of upbraiding his farrier, upbraids the road maker. We would very much like to hear the farriers' views on this vexed question of how we are to pave our streets.

Are there any vested interests in the existing style of shoeing our London horses? would a change in the pattern of horseshoes injure the farriers in any way? There is ever a good profit to be realized from the manufacture of any small object in great numbers—no kind of work pays so well as routine work, work that is mere repetition; and, on the other hand, no industry suffers temporarily from a change to such an extent. We have heard ere now that a change of fashion in ribbons meant pauperism in Coventry. We are sorry no one asked the question whether a change in the fashion of horseshoes would in any way injure the farriers. It has been said that a London farrier usually considers his day's work over before noon. This can be well imagined in one sense, because horses must be shod either before their day's work begins, or after its termination; therefore the mere fitting and nailing-on work would be concluded at an early hour; but it is well known that a set of horseshoes are not "turned," as the farriers term it, from the merchant iron in a few minutes, it is a work of time and labour. May it not be suspected, then, that, working in many cases as they do under contract, the farriers will fit only such pattern of shoe as is most quickly "turned," and with the least expenditure of fuel and iron? The cheapest and simplest shoe is the plain bent plate, such as every horse in London is shod with; the introduction even of a calkin will make a good deal of difference in the cost of producing a shoe. Farriers of all others are the persons who ought to be best fitted to produce a good horseshoe, but are the very class who would suffer in purse for a time by any change. Men and women, unless they desire to go to much increased expense, have to wear any style of boot or shoe which happens to be the prevailing fashion. The trade regulates whether we are to have square toes or round ones. It is to the interest of the trade to alter the fashions, and if possible to improve upon them, consequently men and women are well and comfortably shod. It is to the interest of the farriers that no change should be made in the fashion of horseshoes, and horses and horse-owners suffer. We shall be glad indeed to hear, that whereas asphalt roads have received the honour of a large and influential meeting, horseshoes may soon receive a similar honour, and that a meeting may be convened for the purpose of inquiring, whether it is really impossible to shoe our London horses in a way better adapted for the work they have to perform.

SANITARY WORKS AT WINDSOR CASTLE.[1]

THE drainage and water supply of the Royal domain at Windsor, which for some years have occupied the attention of experts in such matters, and which during that time have occasioned many conflicts of opinion among these authorities, have at length been completed in a manner which leaves little to be desired, and which will probably serve as

[1] From "The Times" of December 8, 1873.

a model for works of a similar character elsewhere. The difficulties of the undertaking were very considerable, and depended partly on the condition of the valley of the Thames itself, partly on the construction of the house drains of the Castle, and partly on the geological formation of the Park. In 1866 the regulation of the upper part of the River Thames was handed over to the Conservators, whose jurisdiction had previously terminated at Staines, and who, on assuming their new responsibilities, found that a portion of Windsor Park was liable to be extensively flooded after seasons of heavy rainfall. It was assumed by many persons that these floods were due to the impediments offered by locks and weirs to the free discharge of the flood water, and it was proposed that all such impediments should be removed and that the river should be left to flow along its natural channel. The portion to be considered was that lying between the Windsor and Eton Bridge and Staines Bridge, a distance of seven miles and a quarter, with a fall of two feet per mile. The average width of the river is about 200 ft.; the depth varies from 4 ft. 6 in. to 10 or 12 ft.; the average flow per day, at the lowest summer level, is about 200,000,000 gallons, and in 1866 there was a difference of ten feet between the lowest summer level and the highest flood level. The whole district is formed by a thick stratum of London clay, over which there are surface beds of Thames drift, gravel, silt, and alluvial deposit. Between Windsor Bridge and Old Windsor Lock the bed of drift gravel under the alluvial deposit varies in depth from 10 to 30 ft., and extends half a mile inland from the river. It is full of water at the level of the river; and this underground bed of water travels, in a line parallel to the stream, at the rate of about half a mile a day. The locks and weirs were three in number—the Bell Lock and Weir, near Egham; Old Windsor Lock and Weir, and Romney Lock and Weir, opposite Eton. They were all in a very dilapidated condition and in constant danger of being swept away by a flood. The bed of the river itself was filled by mounds of gravel which it had brought down, and which greatly obstructed its flow. The summer level could not be maintained at its proper height; and in winter the floods overflowed the banks, covering a large area of surface and doing considerable damage. While this was the state of the river, the drainage of the Castle, and of all the buildings belonging to the Crown in the Home Park, was provided for by a system of culverts, which received not only the sewage of the entire building, but the rain-pipes from 20 acres of roof, and into which the surface rainfall also found access by grated openings. The main sewer of the Castle, and also that of the town, with which many of the Crown buildings communicated, discharged into the river, and were in flood time submerged. The flushing and ventilation of the whole drainage system had been made as good as was possible where rainfall and sewage were conveyed through the same channels; and it was necessary, in any new works which were undertaken, that the best features of the existing ones, and especially the perfect method of daily flushing, which had been tested by many years experience, should be retained; at the same time that the objectionable communication of the rain pipes with the sewers was abolished. In Windsor Great Park, upon a soil of strong clay, there are many buildings subsidiary to the Castle, such as the residences of various officials, and the large hunting establishments, containing altogether about 250 inhabitants and 150 horses. These had for many years laboured under serious difficulties for want of water for ordinary use, and had absolutely no supply which would be available in case of fire; while there were in the immediate neighbourhood about 300 acres of land, the property of the Crown, which would become very valuable for building purposes if supplied with water; but which, for want of it, were hardly even available for pasturage.

When the Conservators of the Thames took possession of the upper part of the river in 1866, they immediately served notices under their Act, directing the Crown to divert all foul drainage from the stream. It therefore became necessary to decide upon the plan by which the requirements of the law were to be complied with, and to consider the possibility of remedying, by some general scheme, the whole of the evils and inconveniences of the then existing state of things. Several eminent engineers and sanitary authorities were consulted, and presented a variety of recommendations upon the subject, all of which were found on investigation to be open to grave objections. One of these plans failed to embrace the basement of Frogmore House, and would have required the construction of a cesspool beneath it. In all of them it was proposed to convey, as formerly, sewage and rain-water through the same conduits; and, on account of the enormous quantity of rain-water to be occasionally provided for, it would not only have been necessary to construct channels of such magnitude that they would have been extremely costly, but also to guard them against bursting by storm overflows into the river, which would have been illegal under the Conservancy Act, would certainly have become nuisances during thunder-storms or other sudden heavy rain following dry weather, and which after protracted rain would have been submerged and rendered useless. The great volume to be dealt with would also have rendered the use of pumps practically impossible as a question of expense, and the fluid could only have been conveyed away by means of gravitation, and, therefore, only to some place which could be approached by a sewer having a fall sufficient for this purpose. The only place fulfilling this essential condition was a plot of land adjoining the Royal domain and at least 50 acres of this land would have been required to absorb the maximum quantity delivered. The land was of the actual value of about £150 an acre, and was in the immediate vicinity of the Home Park, as well as of residences in the occupation of tenants who would have claimed compensation, or who might even have obtained an injunction wholly forbidding the contemplated proceedings. As a matter of agriculture, the irrigation with diluted sewage could not have been profitable, and would only have been a costly method of disposing imperfectly of a nuisance. The scheme of this kind against which the fewest objections could be urged, and which had been brought as nearly as possible to perfection through frequent reconsideration by its promoters would have involved a total outlay of nearly £10,000 more than the plan of separating the sewage from the rainfall which has been ultimately adopted. The additional expense of constructing a sewer large enough to take the two elements together to a place at which they could be dealt with, as compared with the expense of constructing a sewer to take sewage and flushing water alone, was found to be greater than that of putting in separate rainfall-drains for the whole of the buildings under consideration. The sewer for the combined purpose must have had a diameter of at least 2 ft. 6 in., and must have been constructed throughout of brickwork; while the sewage alone could be conveyed through a channel 18 inches in diameter, such as could be made by the employment of the ordinary drain pipes of glazed earthenware.

Mr. Menzies, the Deputy Surveyor of Windsor Forest and Parks, was well known to be an earnest advocate of the general separation of sewage from rainfall, on which subject he had written strongly in 1865, and he was called upon by Mr. Gore, the Commissioner of Her Majesty's Land Revenue, under whose direction Mr. Menzies is placed, and on whom rested the responsibility of considering all schemes affecting the interests of the Land Revenue at Windsor, to report upon the various projects of the engineers and others who were consulted. Mr. Menzies succeeded in showing that all these projects were open to fatal objections, or that they would fail in the fulfilment of conditions essential to success; and, in conjunction with Captain Gun, R.E., he prepared a scheme of his own, which, after being approved on sanitary grounds by Sir William Jenner, was at length laid before Mr. Lowe in his capacity as Chancellor of the Exchequer. Mr. Lowe gave the whole matter his most careful consideration, with the result that the scheme of Mr. Menzies and Captain Gun was adopted by the Government, and was ordered to be carried into effect. It can only be described in connection with the improvements in the river, also suggested by Mr. Menzies, which were undertaken at the joint expense of the Crown and of the Conservancy, and which enabled the present system of drainage to be perfected.

Mr. Menzies pointed out that the proposed removal of the locks and weirs from the river between Windsor and Staines would be open to two very grave objections. In the first place, the removal would lower the summer level of the water by about three feet, and would lower to the same extent the bed of underground water already described, which flows slowly through the gravel by the side of the river. This lowering of the stream would have been bad pictorially, as it would have shut out the view of the surface of the river from many points from which it is now visible, and the lowering of the underground water would probably have affected the old trees in the Park in a very injurious manner. It had always been observed that in dry summers, when the level of the river sank low, the pasturage became burnt up, and also that the old trees, which are principally elms and limes, changed colour and lost their leaves early. The second objection depended upon the tendency of the river to damage its own channel, by excavating holes in some places, and by depositing heaps of gravel in others; and that, if left uncontrolled, it would produce for itself conditions that would cause overflow at uncertain places. The general surface of the Home Park varied from six to seven feet above the ordinary summer level of the river and of the underground water, as they stood in 1866; and Mr. Menzies proposed the construction of works which would at the same time facilitate the escape of flood water and would raise the ordinary summer level instead of depressing it.

For this purpose the bed of the river opposite the Home Park

was cleared of eel bucks and other obstructions, and dredged to an uniform depth of five feet, and the locks and weirs already mentioned were re-built. The new structures were provided with sluices by which to dam up the river to the required height in summer, and also with self-acting tumbling bays, 60 ft. wide, so arranged as to afford an additional passage into the lower part of the river, by the side of the lock or weir, whenever the water rises 15 inches above the fixed summer level. The works last undertaken, those at the Old Windsor Weir, are not yet absolutely completed; but enough has been done, even before the heavy rains of January, 1872, to prove the success of the undertaking. The old flood area had been greatly curtailed, the flood level lowered 18 inches, and the summer level raised at least one foot; so that the difference between these two levels is now only 7 ft. 6 in., instead of being 10 ft. as formerly. The various works enumerated have been designed and executed by Mr. Leach, the engineer to the Conservancy; and the Crown, as an owner of adjacent property, has voluntarily contributed towards the expense.

In a paper read before the Institute of Surveyors, and from which some of the foregoing details have been obtained, Mr. Menzies points out that the limitation of the flood area is likely to be followed by the erection of dwellings upon the reclaimed ground, and on this point he makes the following important observations :—

"Hitherto, the building of all houses on the sides of rivers liable to flood has been regulated by the height to which these rivers rise; and there being no law to interfere with the matter, dwellings generally occupied by the lower classes have been built as far within the flood line as it was possible with decency to go. From this cause we have had occasionally, after the flood waters subside, great outbreaks of epidemic disease, which could clearly be traced to the bad situation of such houses. Inspecting medical officers were then sent among them, and we have received from them and from the house-owners themselves strong recommendations to sweep away all obstructions in the river which appear to cause these floods; quite forgetting the benefits conferred by these structural works in other respects, and how very open a question it is whether the river would not flood to the same extent as it now does, even if the supposed obstructions were removed. I observe already that the lowered level of the Thames in the district under description will be made immediately available by new houses being built within the new water-line; and in a few years hence, when all that has now been done will probably be forgotten, we shall, in all likelihood, have the same complaints renewed and the same remedy suggested. It is a matter well worthy of the attention of the newly-appointed health officers in each county to endeavour to prevent such a state of things from arising."

Between Old Windsor Weir and Old Windsor Lock the river Thames forms a considerable bend of the shape of a horse-shoe, and the nearest points of this bend, at which the weir and the lock are respectively situated, are united by a straight artificial channel to facilitate navigation, which is much used as a boating place by the Eton boys. At the lower end of this channel or cut, and immediately above the Lock which re-admits it into the main stream, water has been taken to turn a turbine, and after passing through the turbine-house is returned into the cut below the lock. The turbine, which was designed and constructed by Messrs. Easton and Anderson, is used to pump water to the various places in which it is required in Windsor Great Park, and also, by an arrangement hereafter to be described, to pump the foul drainage of the Castle to a place where it can be utilized. The improved condition of the river rendered it possible to use the fall at the Old Windsor Lock to work the turbine, and the arrangement of the weirs above and below this lock allows the fall to be rendered tolerably constant. To obtain water, a well was sunk in the gravel, near the lock, and a supply of excellent quality, which promises to be unfailing, was procured. Eighteen thousand gallons daily are now being delivered to the Crown buildings and to the Indian Civil Engineering College at Cooper's Hill, and nearly twelve miles of pipes have been laid down to all parts of the Park where water is required. Some of the superfluous water has also been disposed of to the owners of adjacent property, and thus a rental is obtained which affords some return for the outlay. The highest cistern is 274 ft. above the level of the river, and arrangements are made for a large supply in case of fire.

Contemporaneously with, or in succession to, the various works already described, the necessary arrangements were made for separating the rainfall drainage from the foul drainage of the Castle itself. The whole of the external rain-water pipes were detached from their former connexion with the sewers, and were connected with a new set of rain-water drains, constructed for the purpose. The daily overflow of clean water from the cisterns was taken into the same drains, which were made to discharge, as a temporary measure, into the river, although this clean water will probably be used after a time for the purpose of maintaining the level of the lake at Frogmore. Wherever the rain-pipes had served as sewer ventilators fresh ventilating pipes were inserted, and were carried up to points far above all windows, so that no sewer gas could by their means find entrance into the building. In carrying the sewer across the Park the same principle was acted upon, and the necessary ventilation was afforded by pipes taken up by the sides of tall trees, instead of by openings at the ground level.

An equalizing reservoir to contain sewage was then constructed on the side of the cut already mentioned and about half way between the weir and the lock, and from thence new foul drains were constructed to meet those of the Castle and of the other buildings in the Park, and to receive only the sewage and the water daily used for flushing purposes. The total quantity to be dealt with is thus nearly uniform and perfectly manageable. It flows into the reservoir by gravity, and passes through an iron grating which serves to intercept anything which would be liable to choke the pumps by which it is next dealt with. These pumps take up the sewage and drive it across the cut through a pipe carried by the side of a bridge into a piece of land on the other side of the water, 15 acres in extent, over which it is distributed by ridges and channels, in the usual way of irrigation. Although this land is remote from any habitation, it was thought proper to construct a deodorizing reservoir, but no occasion for its use has ever arisen. The sewers are flushed daily at ten o'clock, the equalizing reservoir is emptied by the pumps almost as soon as it is filled, and the sewage is deposited upon the land without delay.

We have already mentioned the turbine at the Old Windsor Lock, which works the pumps of the water supply. This same turbine works also a pump for compressing air, and the compressed air is then conducted through a pipe to the sewage pumps, a distance of about 500 yards, and is made to work them as it expands. These pumps are put into or out of gear by a float on the surface of the equalizing reservoir; so that as soon as the sewage falls below a certain level the pumps cease to act, and as soon as it again reaches this level their action recommences. When the pumps cease to work, the pressure on the air compressing machine, which usually stands at about 20 lb. to the square inch, steadily increases. As soon as this pressure reaches 50 lb. to the square inch it moves a counter-balanced lever, which pushes aside the driving band of the machine and brings it back again when the pressure descends. The whole apparatus is therefore self-acting. As soon as there is sewage in the reservoir the pumps begin to work, and as soon as their action lowers the air pressure this is renewed by the machine. Both in the turbine-house and at the sewage pumps auxiliary steam-engines have been provided, to be ready in the case of any break down in the other machinery; but up to this time the boiler fires have not been lighted. In an experience now extending over several months the daily working has gone on without a single hitch; and it is worthy of remark that the turbine last winter was submerged beneath 8ft. 6in. of water, by which its action was scarcely impeded.

It is obvious that the use of the turbine to work distant machinery by compressed air (and the distance might be almost indefinitely extended) points to new and hitherto unimagined extensions of water power, and to its employment in the vicinity of rivers and streams for a vast number of purposes.

In the construction of the various works many mechanical difficulties have presented themselves. For the details of these and for the ingenious contrivances by which they have been overcome, as well as for the cost of the various works, we must refer to the paper by Mr. Menzies already mentioned, and to another by Captain Gun in the journal of the Royal Engineers. The total outlay has, in round numbers, been £42,000, of which £30,000 has been paid by the Crown and £12,000 by the Thames Conservancy. The result is a connected series of works which have removed from Windsor Castle and domain every condition which could be injurious to health; which have removed the whole of the foul drainage from the river; which have given an ample and excellent water supply to the residents in the Park and in the adjacent localities; which have greatly increased the value of much of the property affected by them; and which, whether in the comprehensiveness of their general plan or in the perfect adaptation of their several parts, may be fairly taken as furnishing a model of sanitary engineering in the most scientific, as well as in the most practical sense.

THE CHINESE COURT IN THE VIENNA EXHIBITION.

NOW that the Vienna Exhibition is a thing of the past, says a correspondent of "The Times," it seems to me that few incidents connected with its history can be looked back to with greater satisfaction than the fact that the Chinese Government thought it worth while to add its contribution to the specimens of international industry collected there. We have for so long, and with so much reason, been accustomed to look upon the Chinese Government as bent upon maintaining an exclusive reserve in its relations with Western Powers, that we cannot fail to welcome heartily any indications of a desire to change so uncongenial a policy. It must be borne in mind that foreign intercourse with China has already been carried on for over two hundred years. During the whole of that period the Tartar dynasty has been in power; and throughout this long succession of years it has been its principal object to keep back the pernicious foreigner. Every privilege and every right which the foreigner possesses has been wrung from reluctant hands, and on no single occasion, unless we except the Embassy of 1866, has there been anything approaching to a spontaneous desire to enter into friendly communications with Western Powers. It is then particularly satisfactory to find that on this occasion the Chinese Government has broken through its traditional policy and has volunteered to unite on a footing of common equality with other countries in the general promotion of industry and arts. So remarkable is it, indeed, that we should not be surprised to find it regarded by the admirers of the Chinese as an epoch in the international history of the Chinese Empire. At the close of the nineteenth century to regard so ordinary an occurrence as the exhibition of its industrial and natural products at an international show as something extraordinary in the history of an empire numbering more than one-third of the human inhabitants of the globe, is, to say the least of it, somewhat damning praise. At the same time, there are special circumstances connected with the history of China which sufficiently account for the exceptional nature of her international relations, and for our own part we are not inclined to think harshly of a people who cherish with a natural fondness and pride the institutions, habits, and manners with which their name has for centuries been associated; and we can discern quite as much self-respect as arrogance in their reluctance to substitute for the many positive blessings they have achieved for themselves, the doubtful advantages of innovations which they must take on trust. The ship of the State has for a lengthened period been moored in a calm restricted haven, and it is but acting the part of a good captain to ascertain the character of the seas over which he has not yet sailed before committing his bark to their depths. Apart, moreover, from the prudential motives which inexperience necessitates, and from the reluctance to exchange an experimental policy for one, the fruits of which she has tasted and found pleasant, China is so situated that to initiate a policy of reform is to abrogate the claims to infallibility, the belief in which the successive epochs in her history have only tended to strengthen and confirm. For many centuries China was the mistress of the surrounding world. The neighbouring states with which she came in contact she found ignorant as herself of anything beyond their immediate vicinity, and greatly inferior to her in intelligence. The consequence was that she came to look upon herself as the world, or rather as the centre of the system round which all other states revolved as satellites. These states were incorporated into her body politic, and so long a time elapsed before anything occurred to disturb the pleasing illusion of her infallibility that her assumptions became embodied in her language and in the everyday talk of the people, who never referred to their own country but as to the "Middle Kingdom" or the "Universe." It was, after all, but another exemplification of the proverb—"Among the blind the one-eyed man is king;" and the history of the human race affords endless proof that conceit and pride increase in exact ratio with the limitations of experience and knowledge. The history of the last 100 years has been the chronicling of a series of shocks upon this time-honoured creed, and their rudeness has been proportioned to the determination of the Chinese to resist rather than to bend before the storm. Much has been done, but much still remains to be done. The growth of centuries cannot be uprooted in a moment, and we fear the dislike to acknowledge an equal is still strong in the minds of the people. Foreigners will be "devils" and "barbarians" for some time to come yet. It is only by example, firmness, and uprightness that we can hope to eradicate these prejudices; and, meanwhile, we can welcome with hearty appreciation any effort on the part of the Chinese Government, however small, to grasp a truer, though less flattering, appreciation of her position in the world. The appearance of China in the Vienna International Exhibition was a good omen for the future, and sufficiently indicated her disposition to enlist herself on a footing of equality in the ranks of the international comity. The collection of articles presented for inspection afforded only another proof of what has always been allowed—the ingenious intelligence of the people, their fertility of resource, and their untiring industry; and without being a partial observer one could discern in the collection the promise of an important future under the educating influences of enlarged experience.

COAL IN SARAWAK.

A CORRESPONDENT writes to "The Times":—"In the Parliamentary Report on coal, 1873, it is stated that the coal exported to foreign countries has increased from 9,283,294 tons in 1865 to 13,211,961 tons in 1872," and it will be instructive to notice what sources of supply may assist in lessening this outflow, since the more coal that is available for steam and industrial purposes at home, the better our manufacturers will be able to maintain that command of foreign markets which has hitherto been regarded as the heritage of this country. While the New South Wales coal is meeting the demand in the southern hemisphere, and a considerable portion of the coal used in North China and Japan is drawn from the latter country, large deposits of bituminous, anthracite, and cannel coal have been brought to light in Sarawak during the past twelve months, where exploring parties have been organized by the Rajah Brooke. There is now little doubt that, sooner or later, Singapore, Hongkong, the Malay Archipelago, and perhaps Galle, will be supplied with Sarawak coal of a quality to meet every requirement for steam, gas, or other purposes. The Sarawak government is now working a vein of coal for the use of its own steamers a short distance up the Sadong River, not far from the sea; this is inferior in quality and very easy of access. Near Mukah, on the sea coast of the Mukah Residency, a vein of cannel coal of great thickness has been traced for a considerable distance, and been found cropping out in fourteen different places over an area of 20 miles. A vein of similar cannel has been discovered up the Rajong River, which is navigable nearly 200 miles for small steamers; and many other outcrops of coal have been brought to light, of which that found in large quantities at Silantek has proved the most important. This latter, a steam coal stated to be equal to West Hartley, has been raised, and tried at Singapore with remarkable results. This trial was made on board the steamship "Agnes," fitted with ordinary compound surface-condensing engines, the diameters being 47½ in. in the high pressure and 25½ in the low pressure cylinder, with a stroke of 2 ft. 9 in. During the 6¼ hours the vessel was at full speed at sea the steam was from 50 lb. to 55 lb. pressure in the boiler, and indicator cards taken every half-hour, gave a mean horse power of 330·71; 4,196 lb. of coal was weighed and consumed, giving an average of 762 lb. per hour; an equivalent of 2 lb. 6 oz. per indicated horse power per hour; the furnace refuse was 7½ per-cent. of coal consumed; the combustion was perfect, with a very little light grey smoke. Making the usual allowances, it may be taken that less than 3 lb. per horse power per hour would suffice on an ordinary voyage. The coal used was surface coal, and could hardly be expected to yield its full power. The crop of the main seam of this Silantek coal has been opened up for nearly two miles; it runs from four to five feet thick, and is available for surface working at a gentle angle. Quite lately coal of the same kind as the above has been found at the mouth of the Sibuyan River, near the sea, where it crops out of six hills of a considerable size and has many facilities for working. The existence of these deposits, and their utilization through the medium of Chinese labour, can hardly fail to be a matter of importance to our Eastern carrying trade, and all interested may hope that the bad name attaching to Eastern coal will become a thing of the past. There are few points in the far East where it is more important to command an unfailing supply of steam fuel than at Singapore and the Straits of Sunda; our China trade cannot fail to welcome its production, and the newly projected railways in Java will doubtless create a local demand for good coal which at present it is difficult to meet."

SIR WILLIAM FAIRBAIRN.

THE SCIENCE OF MODERN COTTON SPINNING.[1]

SINCE the publication of Baines's "History of the Cotton Manufacture in Great Britain," no work at all to be compared with Mr. Evan Leigh's "Science of Modern Cotton Spinning," the full title of which we give below, has appeared in this or any other country. It is at one and the same time comprehensive, simple and practical. It gives us the results of wide reading, observation, and personal acquaintance with the subject of which it treats. Indeed, no one not himself intimate with the various processes of the manufacture, could possibly have produced such a work; abounding as it does in technicalities, and notices of the various inventions and improvements which have successively led to the high position, which the science of cotton spinning at present holds in our country. In addition, let us remark that the subject is treated in such perspicuous and well-chosen language, that even our friend the *general reader*, may peruse Mr. Leigh's book not alone for his instruction, but for his entertainment.

After these few words of commendation, we shall proceed to notice some of the principal features in the work before us, making extracts as we go on, accompanied occasionally with wood-cut illustrations.

In ancient times, the native country of the cotton-plant was India. It may have been, and doubtless was, indigenous in other regions, the inhabitants of which made no use of it; but in India it has been spun and woven into cloth from time immemorial. Herodotus, in mentioning the valuable products for which India was remarkable in his times, states that "the wild trees in that country bear fleeces as their fruit, surpassing those of sheep in beauty and excellence, and the Indians use cloth from these trees." Ctesias, Theophrastus, Arrian, and other Greek writers mention it in somewhat similar terms. It does not appear that the cloth so manufactured was regularly exported into Greece; but that it found its way into Rome at a subsequent period is apparent from several passages occurring in the Roman writers. At first, the use of it was regarded as an extreme luxury, but in process of time it came to be imported into Europe in larger quantities as a manufactured article, and eventually in the raw state. But, as in India originally the only process used in cotton spinning was that of the distaff and spindle, one remarkably slow and comparatively unremunerative, so it continued to be in Europe (our own country included), until the introduction of the spinning wheel, which did not mend matters very much, since only one thread at a time was produced by it. Such was the condition of our cotton manufacture until about the middle of the last century. Wool was the staple commodity of England, which it was sought to bolster up by all kinds of legislative enactments, while the manufacture of cotton was pursued as a mere domestic employment. When Dyer, more deservedly now known as the author of "Grongar Hill," produced his poem of "The Fleece," he little dreamt how soon the wool staple was to succumb to that of cotton. Dyer's poem, first published in 1757, may be regarded as an apotheosis of the original staple, so soon destined to be displaced. It was upon the whole unworthy of his genius, and we trust that some future poet may be more successful in singing of the manufacture of cotton cloth.

Mr. Leigh very fitly commences his work with an account of the various descriptions of cotton grown in different countries; particularizing the length and fineness of the staple. Thus he tells us that "the Sea Island cotton of Georgia surpasses all other varieties in length and fineness of staple; that grown on the Edisto Island having the longest staple of all." This variety commands the highest price in the market on account of its general excellence, silkiness, and beautiful gloss. It has

[1] *The Science of Modern Cotton Spinning, embracing mill architecture, machinery for cotton ginning, opening, scutching, preparing, and spinning, with all the latest improvements; also articles on steam and water power; shafting; gearing, and American system of belting compared; generation, and application of steam criticized and explained; boilers, boiler explosions, &c.; all tending to show where the outlay of capital may be economized and production cheapened.* By Evan Leigh, C. E., inventor of "coupled mules" with "putting-up motion," "self-stripping carding-engine," "loose boss top roller," &c. Second edition. 2 vols. Manchester: Palmer and Howe. London: Simpkin, Marshall and Co.

found a rival, however, in some parts of Australia, Tahiti and others of the South Sea Islands. The diagrams on page 34 show the comparative length of the staple both in the cotton of the Sea Islands and of Australia.

Next in value comes the Egyptian cotton; next the Brazil and other South American cotton; next the cotton of Algeria; and next that of the West Indies. The diagrams on pages 34 and 35 show the length of staple in all these.

The comparative length of staple in other cottons is shown in the diagrams on pages 36 and 37.

Whatever the variety of the cotton, and whatever its length or fineness of staple, the first process it has to go through before any use can be made of it, is that of "ginning." "Ginning cotton means the separating of the cotton from the husk or berry, to which it most tenaciously adheres; some kinds having green, woolly seed, and others brown seed, like roasted coffee. Every boll of cotton has a berry inside, which resembles unground coffee. The earliest attempt at ginning of which we have any account, is the crushing of the seed and cotton together, by placing it on a flag and rolling a bar of iron over it with the foot, a method still practised in some parts of India. Next comes the churka or roller gin, which is made of two round pieces of hard wood fixed in a rude frame. This machine is extremely simple and produces a better quality of work, but with much labour. It was followed by 'a roller gin' with fly-wheel, which requires two persons to work it, one turning the upper roller with a staff, the other working the under roller with a crank, and feeding the cotton at the same time. Churka gins, with iron or steel rollers, have been made both for hand and power, but do not appear to have come into very extensive use." To the "churka" succeeded the "saw gin," invented by Eli Whitney; the "Macarthy gin" taking its name from the inventor, and "singularly well adapted for long-stapled cottons;" the "knife-roller gin," first used in Oldham, and afterwards with improvements, in Bolton; the "lock-jaw cotton gin" (Cowper's patent). With respect to this gin, our author observes :—

"This gin has a roller similar to the Macarthy, but it acts in a different manner. In place of the usual 'doctor,' there is a 'moving nipping blade,' which presses the fibres of the cotton to the leather roller, just at the moment the seed is detached by the action of the beater. The roller has a continuous motion, the same as in the Macarthy, but the 'nipping blade,' like the beater, is intermittent. There is also a fixed blade in advance of the nipper, which is set close to but not pressing upon the roller.

"The object sought to be accomplished by this is to prevent the gin choking, and effect a saving of power, as well as wear of the leather-covered roller, by avoiding the constant pressure which an ordinary doctor has upon it. In order that the nipping blade may hold the cotton down to the roller a sufficient length of time for the beater to strike, and still avoid the rubbing friction on the leather, it is made to move a short distance with the roller, after making its nip, and pulls the cotton through.

"The idea in this machine is very good, and its application scientific, but the extra parts required to effect these different movements tell against it, as well as the additional cost, and the danger is that it may be found too far advanced for the cotton-growing countries, and, without even a fair trial, be consigned, like the double-roller gin, to 'the tomb of all the Capulets,' as many other excellent inventions have been, that were both intended, and well calculated under more intelligent management, to ameliorate the present rude system of ginning.

"Such of these inventions as are based on true principles will not lie for ever dormant, but in due time will appear again, under a new garb, it may be, simplified and improved, but practically the same."

In a postscript Mr. Leigh notices two other improvements recently brought to his knowledge; one an invention of Mr. E. Jones and Dr. Forbes, in India, the other an invention of American origin. With respect to these he remarks: "The combined effect of these two improvements may have an important bearing upon the ginning of cotton; and if to this be added the rapid recovery of the Southern States of America, the further development of the railway and irrigation systems in India, and the wonderful promise held out by Mr. Login's experiments, it becomes highly probable that the dreary depression which for nearly ten years has hung over the cotton manufacture, occasioned by the short supplies of the raw material, will now speedily pass away."

The next subject of which Mr. Leigh treats is "Cotton-mill Architecture," to which he devotes a chapter well worth the attention of practical cotton spinners. It contains much valuable advice, and is illustrated by a series of plans showing the construction of the "India mill," at Darwen, "one of the noblest specimens of mill-architecture which this country affords." In mill-architecture, as well as for the construction of cottages, Mr. Leigh strongly advocates the use of artificial stone, what the French call *Béton Aggloméré*, the manufacture of which is very cheap, if properly attended to.

"The works," he says, "already executed, and thoroughly tested, in artificial stone are sufficient to convince the most sceptical of its rising importance to mill and cottage architecture: to the former, as tending to cheaper and dryer establishments; and to the latter, as far more comfortable and convenient dwellings for the operatives employed, without increase of rent. Solicitude for the happiness and well-being of all those engaged about a manufactory should never be wanting in the owner or manager, as it tends to success. It is like sowing good seed on fertile ground, which springs up and flourishes, producing sometimes fifty-fold, sometimes one hundred-fold. This care may be carried with advantage much farther than the mere comfort of dwellings; and wherever the experiment has been tried of looking after the moral and intellectual wants, as well as the amusements, of those families located on the spot, it has always been gratefully appreciated, and redounded to the honour and satisfaction of the employer."

We pass over the chapter on "Gearing and Belting," in order to give space for the following judicious remarks introduced by the author in his section on "Moving Power."

"It is especially undesirable," he says, "for driving machinery at its present rapid rate, to commence with a very slow motion, not only on account of the extra outlay in engines, gearing, and foundations, but the jerking caused in getting over the centres, loss of power, and various other inconveniences. For instance, a great and unsuspected loss of power occurs with slow running engines, through the chill which the internal surfaces of the cylinders acquire by being so long in communication with the condensors. Another loss is caused through the enormously extra weight of fly-wheels required and the friction of heavy shafts.

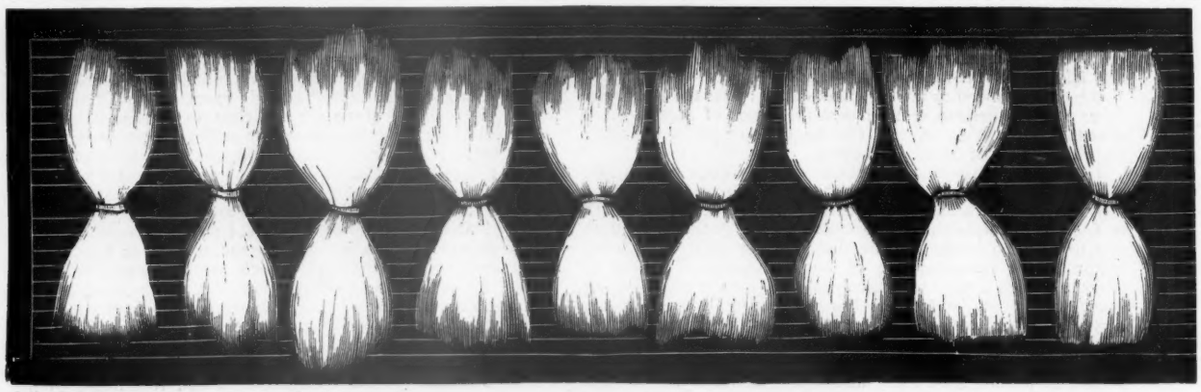
"Disastrous breakdowns often occur also with power established on this principle, when so much speed has to be brought up. It is like taking a short lever to lift a heavy weight. Ponderous beams may do very well for pumping-engines where only slow motion is required, but it is thought erroneous to employ either the beam or heavy gearing when a rapid rotary motion is wanted. That modern practice has been tending in this direction may be seen in many new mills in which the beam engine, though not all of the heavy gearing, is altogether discarded. The greater the speed of the first motion shaft the lighter the fly-wheel required, and the danger is less. Double the speed of a fly-wheel shaft, and *one-fourth* the weight of fly-wheel will suffice, the centrifugal power being as the square of the velocity. It should be particularly impressed on the mind of the student that a heavy fly-wheel is not only a loss of power, but that the enormous force concentrated in its momentum cannot be suddenly checked when anything goes wrong—such as the breaking of a large driving-wheel or shaft—it goes off at an accelerated speed, tearing down all before it. Hence so many fearful and expensive crashes where beam engines with heavy rumbling gearing are employed. Cannot all this be avoided, and power be made relatively as safe as a fire-proof mill over one that is not so?

"This most certainly may be done, and the anxiety removed. Good and desirable things, generally, are only to be dearly purchased; but here is a notable exception, for this great benefit may be had for less money, less consumption of fuel, and steadier turning withal, which is of especial value. How then shall this desirable end be attained? Let prejudice be cast away and a common sense view be taken of the existing appliances of steam to a thousand other purposes than the driving of mills, and it will be perceived that as to the propelling of works without the expensive paraphernalia of beam, or heavy and noisy gearing, there is no mystery. Simplicity is always charming, but especially so about an engine and millwork. It saves the pocket, it adds to security, it lessens the interest of capital and depreciation. Example: Suppose it is required to run the main shaft in the bottom room 100 revolutions per minute; take hold of that shaft at once with the engine connecting-rod, or with the piston-rod, if the engine be an oscillating one. A very light fly-wheel only will then be necessary to get the engine over the centre, and no gearing or very massive foundation-work will be required. The noise also will disappear. Theoretically, a fly-wheel of only *one sixteenth* the weight would be required to what would be necessary for an engine making only 25 strokes per minute; but as a smaller diameter of wheel would be put on the fast engine, the real difference in weight might be about nine-tenths less metal, and perhaps nine-tenths less cost for the fast than for the slow running fly-wheel. Nor does the advantage end here, for such an engine, complete, only costs about one-fourth, or less than a fourth of the price of the 25-stroke engine per indicated horse power, and the turning is steadier. The

COTTON GROWN IN VARIOUS PARTS OF THE WORLD.—Comparative Length of Staple.

Description.	SEA ISLAND OR LONG STAPLE.							
Place of Growth.	Sea Island.	Edisto Island.	John's Island.	James Island.	St. Helen's Is.	Wadamalan I.	Wassa Island.	Hutchinson I.

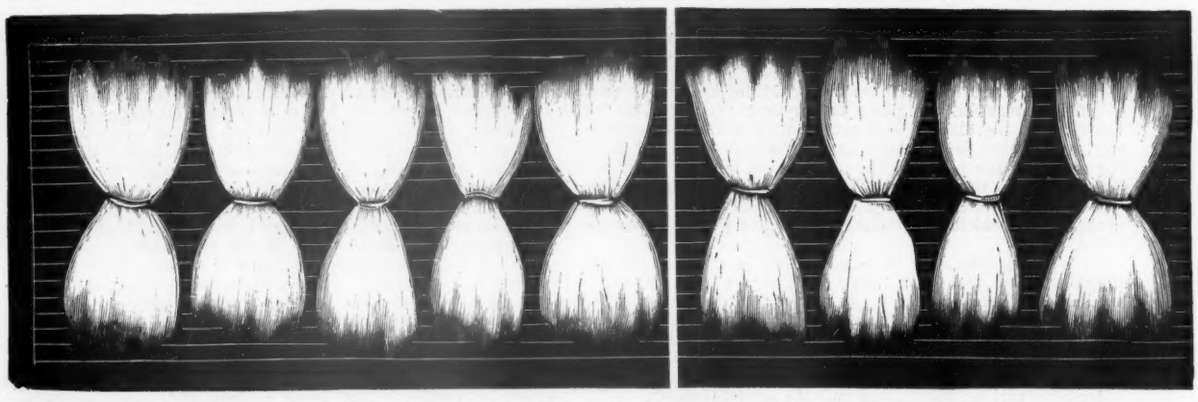
Two Inches, divided into 10ths.



Number . .	1	2	3	4	5	6	7	8	9
Min. Length	1·60	1·40	1·90	1·40	1·45	1·55	1·40	1·45	1·40
Max. „	1·80	1·70	2·30	1·80	1·75	2·00	1·85	1·85	1·90
Mean „	1·70	1·55	2·20	1·60	1·60	1·78	1·63	1·65	1·65

Description.	SEA ISLAND (*Continuea*).					AUSTRALIA.	
Place of Growth.	Bull's Island.	Pinkey Island.	Bluff Island.	Cat Island.	Florida Island.		Moreton Bay.

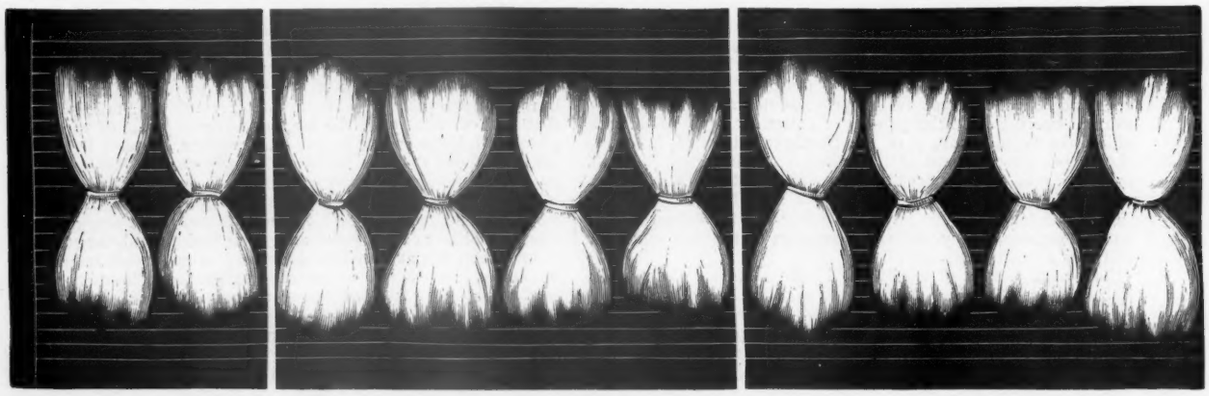
Two Inches, divided into 10ths.



Number . .	10	11	12	13	14	1	2	3	4
Min. Length	1·30	1·20	1·60	1·20	1·30	1·50	1·60	1·40	1·30
Max. „	1·75	1·60	2·00	1·65	1·85	1·80	2·00	1·60	1·70
Mean „	1·53	1·40	1·80	1·43	1·58	1·65	1·80	1·50	1·50

Description.	EGYPT.	WEST INDIES.				SOUTH AMERICA.	
Place of Growth.	Egypt.	Union Isl.	St. Kitt's Isl.	Carriacon.	St. Vincent.	Pernambuco.	Peru.

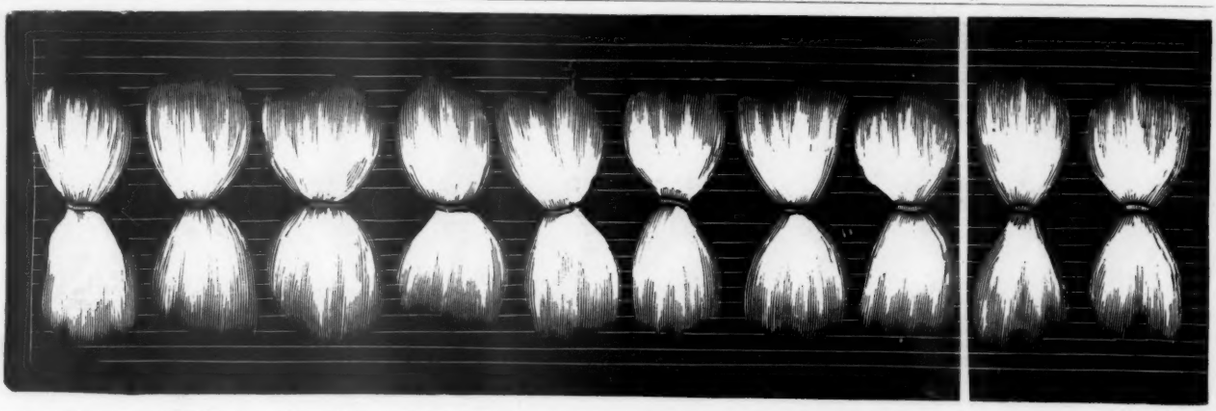
Two Inches, divided into 10ths.



Number . .	1	2	1	2	3	4	1	2	3	4
Min. Length	1·40	1·20	1·30	1·20	1·10	0·90	1·20	1·10	0·90	1·10
Max. „	1.60	1·50	1·60	1·40	1·30	1·20	1·50	1·40	1·30	1·50
Mean „	1·50	1·35	1·45	1·30	1·20	1·05	1·35	1·25	1·10	1·30

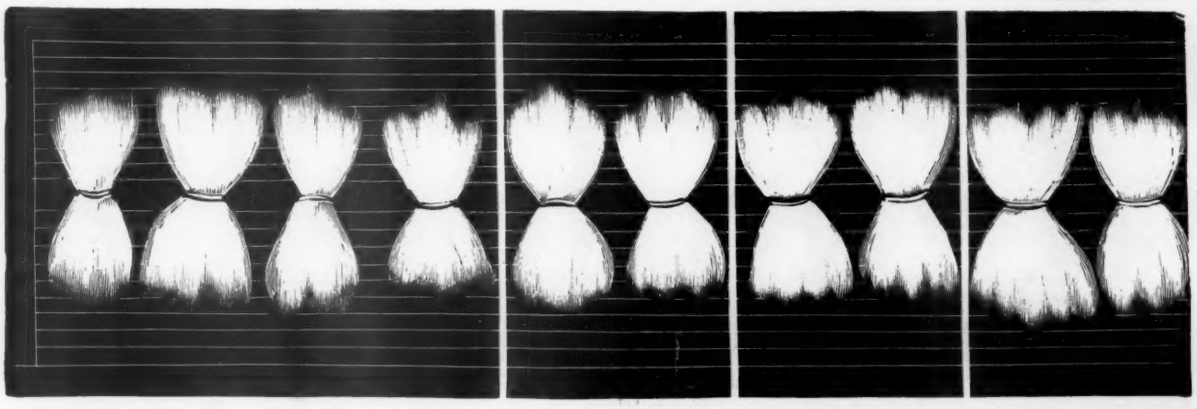
COTTON GROWN IN VARIOUS PARTS OF THE WORLD.—Comparative Length of Staple.

Description.	SOUTH AMERICA (*Continued*).						ALGIERS.	
Place of Growth.	Surinam.	Aracate.	Maranham.	Paraiba.	Ceara.	Maceo.	Algiers.	



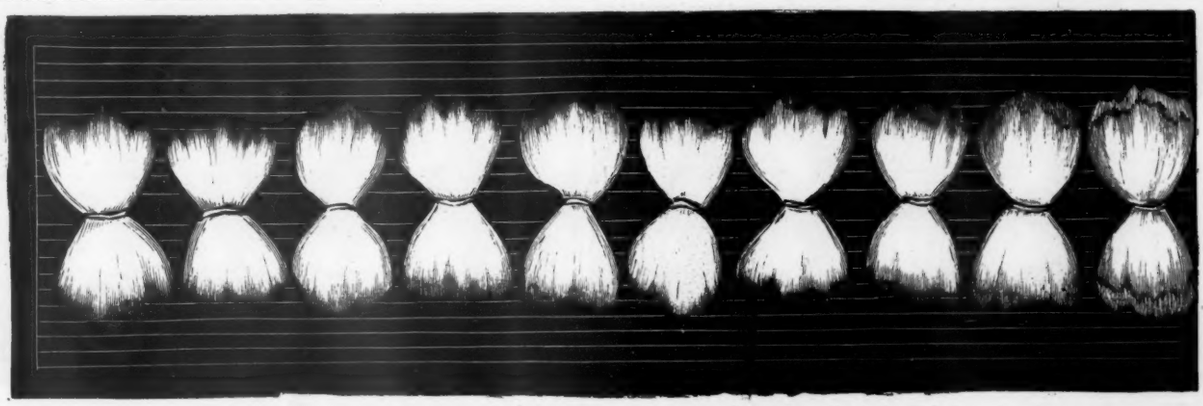
Number. . .	5	6	7	8	9	10	11	12	1	2
Min. Length .	1·10	0·90	1·00	1·00	0.90	1·10	1·00	1·10	1·40	1·30
Max. „ .	1·50	1·20	1·30	1·30	1·30	1·30	1·30	1·30	1·60	1·50
Mean „ .	1·30	1·05	1·15	1·15	1·10	1·20	1·15	1·20	1·50	1·40

Description.	WEST COAST AFRICA.				PORT NATAL.		BORNEO AND JAVA.		UNITED STATES.	
Place of Growth.	Lagada.	Shire Valley.	Loanda.	Lagos.	Port Natal.		Sarawak.	Java.	Mississippi.	



Number. . .	1	2	3	4	1	2	1	2	1	2
Min. Length .	1·10	1·00	0·90	0·80	1·00	0·90	1·10	1·00	0·90	0·90
Max. „ .	1·20	1·30	1·20	1·00	1·20	1·20	1·30	1·20	1·30	1·20
Mean „ .	1·15	1·15	1·05	0·90	1·10	1·05	1·20	1·10	1·10	1·05

Description.	UNITED STATES—UPLANDS (*Continued*).								
Place of Growth.	Texas.		Louisiana.	Tennessee.	Mobile.	Alabama.	Georgia.	South Carolina.	



Number. . .	3	4	5	6	7	8	9	10	11	12
Min. Length .	0·90	0·70	0·70	1·00	1·00	0·90	0·90	1·00	0·90	0·80
Max. „ .	1·20	1·00	1·00	1·20	1·20	1·00	1·20	1·10	1·20	1·20
Mean „ .	1·05	0·85	0·85	1·10	1·10	0·98	1·05	1·05	1·05	1·00

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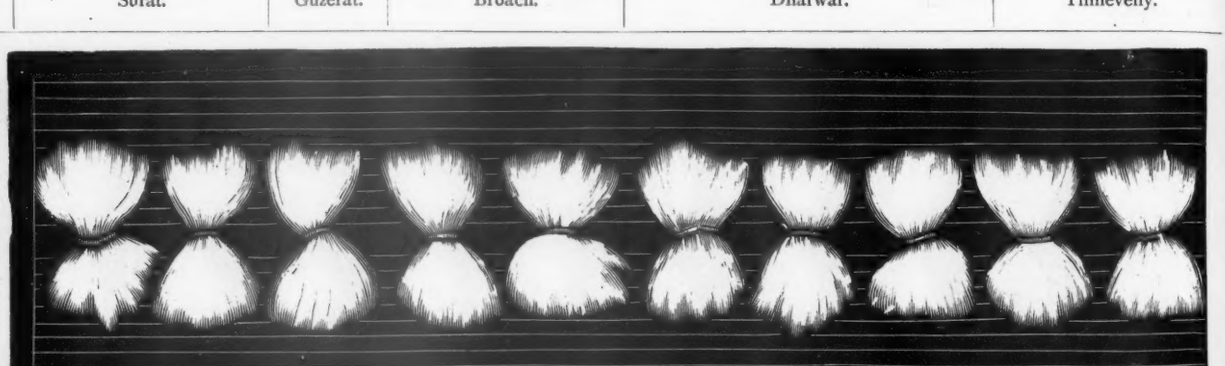
COTTON GROWN IN INDIA.—Comparative Length of Staple.

Description.	NATIVE OR INDIGENOUS.				
Place of Growth.	Surat.	Guzerat.	Broach.	Dharwar.	Tinnevelly.

Two Inches, divided into 10ths.



Number. . .	1	2	3	4	5	6	7	8	9	10
Min. Length .	1·00	0·80	0·90	0·80	0·60	0·90	0·90	0·80	0·90	0·80
Max. „ .	1·20	1·20	1·20	1·00	0·90	1·20	1·10	1·00	1·20	1·10
Mean „ .	1·10	1·00	1·05	0·90	0·75	1·05	1·00	0·90	1·05	0·95

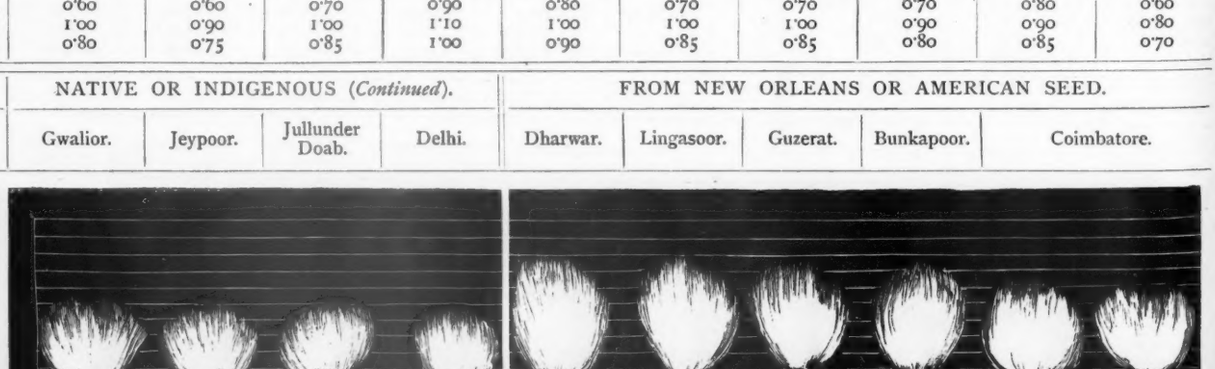
Description.	NATIVE OR INDIGENOUS (*Continued*).								
Place of Growth.	Trichinopoly.	Tinnevelly.	Coimbatore.	Candeish.	Berar.	Amednuggur.	Belgaum.	Madras.	Agra.

Two Inches, divided into 10ths.

Number. . .	11	12	13	14	15	16	17	18	19	20
Min. Length .	0·60	0·60	0·70	0·90	0·80	0·70	0·70	0·70	0·80	0·60
Max. „ .	1·00	0·90	1·00	1·10	1·00	1·00	1·00	0·90	0·90	0·80
Mean „ .	0·80	0·75	0·85	1·00	0·90	0·85	0·85	0·80	0·85	0·70

Description.	NATIVE OR INDIGENOUS (*Continued*).				FROM NEW ORLEANS OR AMERICAN SEED.				
Place of Growth.	Gwalior.	Jeypoor.	Jullunder Doab.	Delhi.	Dharwar.	Lingasoor.	Guzerat.	Bunkapoor.	Coimbatore.

Two Inches, divided into 10ths.

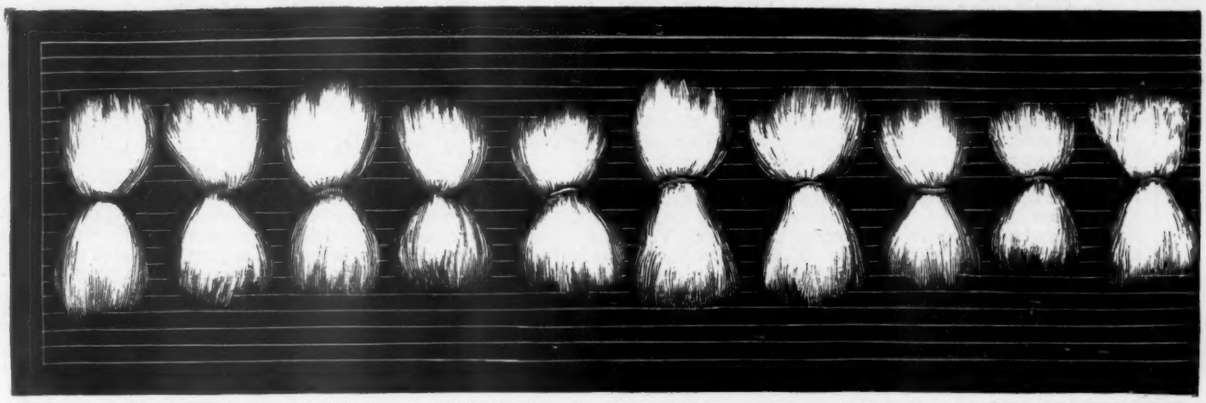


Number. . .	21	22	23	24	25	26	27	28	29	30
Min. Length .	0·70	0·70	0·70	0·50	1·15	0·90	0·90	0·90	1·10	0·80
Max. „ .	0·90	0·90	0·80	0·80	1·50	1·20	1·30	1·20	1·20	1·10
Mean „ .	0·80	0·80	0·75	0·65	1·33	1·05	1·10	1·05	1·15	0·95

COTTON GROWN IN INDIA.—Comparative Length of Staple.

Description.	FROM AMERICAN SEED (*Continued*).						
Place of Growth.	Dharwar.	Belgaum.	Travancore.	Mysore.	Bolarum.	Sheopoor.	Tenasserim.

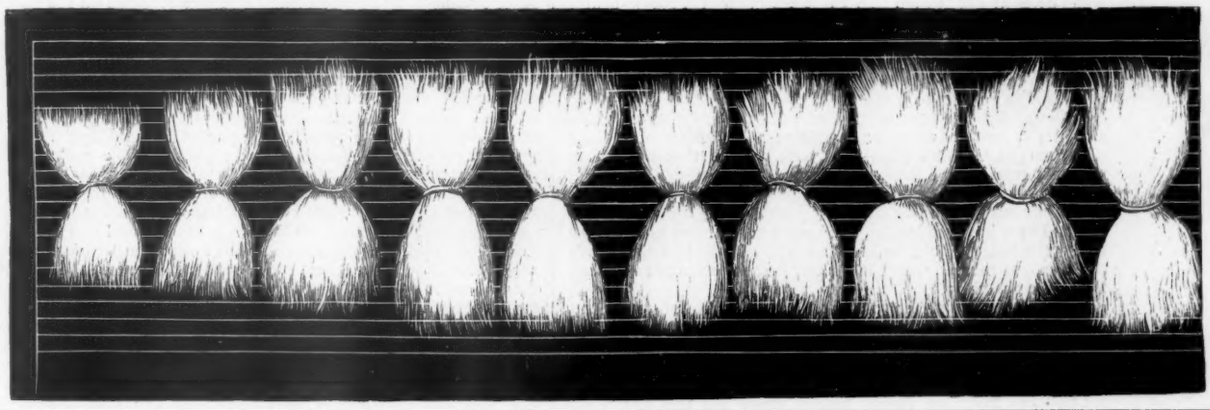
Two Inches, divided into 10ths.



Number . . .	31	32	33	34	35	36	37	38	39	40
Min. Length .	1·30	0·90	1·30	0·80	0·80	1·10	0·90	0·80	0·90	1·10
Max. „ .	1·70	1·20	1·50	1·00	1·10	1·50	1·20	1·00	1·10	1·30
Mean „ .	1·50	1·05	1·40	0·90	0·95	1·30	1·05	0·90	1·00	1·20

Description.	FROM SEA ISLAND AND EGYPTIAN SEED.				
Place of Growth.	Belarum.	Bengal.	Mysore.	Dharwar.	Hooblee.

Two Inches, divided into 10ths.



Number . . .	41	42	43	44	45	46	47	48	49	50
Min. Length .	0·90	1·00	1·40	1·50	1·50	1·30	0·90	1·40	1·20	1·40
Max. „ .	1·10	1·30	1·75	1·70	1·80	1·70	1·10	1·60	1·50	1·80
Mean „ .	1·00	1·15	1·57	1·60	1·65	1·55	1·00	1·50	1·35	1·60

SUMMARY OF RESULTS.

Place of Growth.	Description of Cotton.	Length of Staple.				Diameter of Individual Fibres or Filaments.			
		In inches and decimals.			Fractions.	In decimals of an inch.			Fractions.
		Min.	Max.	Mean.	Mean.	Min.	Max.	Mean.	Mean.
United States	New Orleans or Uplands . . .	0·88	1·16	1·02	$1\frac{1}{50}$″	·000580	·000970	·000775	$\frac{1}{1209}$
Sea Islands	Long Stapled	1·41	1·80	1·61	$1\frac{60}{100}$″	·000460	·000820	·000640	$\frac{1}{1562}$
South America . . .	Brazilian	1·03	1·31	1·17	$1\frac{17}{100}$″	·000620	·000960	·000790	$\frac{1}{1265}$
Egypt	Egyptian	1·30	1·52	1·41	$1\frac{41}{100}$″	·000590	·000720	·000655	$\frac{1}{1526}$
India	Indigenous or Native	0·77	1·02	0·89	$\frac{89}{100}$″	·000649	·001040	·000844	$\frac{1}{1185}$
	Exotic or American	0·95	1·21	1·08	$1\frac{2}{25}$″	·000654	·000996	·000825	$\frac{1}{1212}$
	Sea Island and Egyptian . . .	1·36	1·65	1·50	$1\frac{1}{2}$″	·000596	·000864	·000730	$\frac{1}{1369}$

consumption of coal is likewise much less, for the power lost in turning the heavy fly-wheel, ponderous shafting, and gearing of the slow running engine is saved, and the cooling of the internal surface of the cylinder, already spoken of, is to a great extent prevented by the velocity."

We now come to the important processes involved in "cotton mixing, opening, and scutching." The "scutcher" is a most important machine in the practice of cotton spinning, of which Lord's "finisher scutcher" is a good example. Mr. Leigh, however, appears to prefer the single-beater finisher lap machine on Crighton's principle (fig. 52), page 39, which he explains thus :—

"The next example (fig. 52) shows section of a single-beater finisher lap machine on Crighton's principle, in which it will be seen that the beater A has two knives; and the feed rollers E are placed a little above the centre of the beater. The leaf extractor D is a travelling lattice with transverse bars, between the interstices of which light leaf is collected and emptied out under the machine as it revolves in the opposite direction to the course of the cotton. In this example the upper dust cage, B, is about 22 inches diameter, and the lower one 19 inches; and there is only one pair of heavily-weighted callender rollers to condense the cotton before it goes on the lap."

"Another example (fig. 54) is a section of a finisher lap machine as made by several makers. It has a triple knife beater (18 inches diameter), a stationary box leaf extractor with a let-down bottom, dust cages of equal diameter (about 23 inches), and four callender rollers to condense the cotton before being rolled up into a lap. It has two pairs of plain fluted feed rollers, to prevent slipping or snatching of the cotton. It is hardly necessary to refer in detail to all the letters in the figure, as it will be understood from the preceding descriptions. It may, however, be remarked that the plan of condensing the cotton by four callender rollers, by which the cotton gets pressed three times before being rolled on the lap, appears to have some advantage, and works well in practice.

"The next illustration (fig. 55) is a section of a single-beater finisher lap machine, which differs in several particulars from those previously described."

The "scutching-room" itself, with its uses and form of construction, is well described, the author concluding his recommendations with respect to it as follows :—

"The plan of the scutching-room will have to be arranged, as a matter of course, to suit the machines it is decided to use, and wherever practicable it should be so contrived that the cotton will pass straight on from the cotton store to the opening and scutching machines, and the laps from these delivered at the most convenient point for the cards; all turning back should be avoided as a waste of labour. Where it is intended to stack the cotton the bales should be elevated and opened in a room over the bins it is mixed in, and the latter be as convenient as possible to the scutchers.

"Some spinners prefer to hoist the bales of cotton to the top of the mill at once, and have their cotton store, mixing, and scutching in the attic, the card room being next below, then spinning all the way down, ending with throstles or looms on the ground floor; the object being to save the labour of carrying the bobbins from the roving frames, when full and heavy, up stairs to be spun, and the sets of cops down again.

"This should never be done where the mill is not fireproof, and, since the establishment of hoists, it becomes altogether unnecessary; indeed, such arrangement of machinery is very properly discarded in modern mills. Under any circumstances the scutching and mixing rooms should be fireproof, as fires very often take place through hard substances, which have been packed up in the cotton, coming in contact with the beaters."

On the process of carding and the machines connected with it, Mr. Leigh has bestowed considerable attention. Of the carding engine he tells us :—

"This machine is one of the most important employed in the whole system of the cotton manufacture; indeed it may be said to hold the very first rank.

"Although the principle of carding remains virtually the same as it was in the days of Arkwright, still the opinions of spinners differ so widely on this subject that carding engines continue to be made in a great variety of forms.

"The plans of scutching, drawing, slubbing, roving, and spinning have been tolerably well established, and become questions of mere excellence or quality of construction by different machinists, who have competed with each other for public favour, showing but little variety in detail, and none, or next to none, in principle, spinners having long ago made up their minds as to the *modus operandi* of converting cotton into yarn; but whenever a man professes to enlighten the public on the subject of *carding*, he soon gets himself into a hornet's nest.

"Deduction from facts, philosophy, and reason, so powerful in elucidating the truth in other matters, seem in this to lose their potency, and leave the question still debatable, as if by common consent spinners had herein agreed to differ. Nor can this be wondered at when one looks around and sees the great variety of constructions by ingenious and earnest men, who have laboured hard and patiently to excel in this most important branch of the cotton manufacture. Every inventor clings to his own production and defends it with all his might; faults it may have, plain enough to others, but he sees them not—

> 'O, wad some power the giftie gie us,
> To see oursels as ithers see us.'—BURNS.

"But, lacking this power and despairing of the ability to settle the question, it is proposed first to give a short historical account of the invention of the carding engine, and then proceed to describe, analyze, and criticize the most recent inventions and alleged improvements in carding engines, and leave the reader to form his own opinions thereon, premising that whatever system be adopted, very much depends upon management.

"Carding, as practised with rude machinery, is of so great antiquity that history fails distinctly to trace its origin.

"After cotton is ginned, picked, and prepared—whether this be done by the old Indian bow, the batting flake, or the modern system of opening and scutching by machinery—its fibres are found matted together and lying in all directions; therefore, before they can be twisted into a thread it is necessary to stretch them out and lay them parallel side by side, but as they have a tendency to curl, frequent combing or brushing is required, both to lay the fibres straight and to take out the light motes, nep, and other impurities.

"The earliest account we have of this is as follows :—Two wire brushes were made, with the wire bent to an angle; they were about four inches wide and about twelve inches long; one of them being nailed to a bench, the other having a handle to be held by the operator in passing it to and fro over the fixed card, upon which the cotton to be operated upon was placed. After sufficient carding or combing it was stripped off the cards by a rod set with spikes or needles, termed a 'needlestick,' after which it was spun upon the one-thread wheel or distaff. The first improvement recorded upon this rude machine appears to have been made by James Hargreaves (the inventor of the spinning jenny), a weaver of Blackburn, and contemporary of Arkwright. This improvement consisted in suspending the top or moveable card by two cords which passed over pulleys and had a weight attached to the other end; which simple contrivance relieved the operator so much that the 'stock cards,' as they were termed, were made considerably longer, and much more as well as better work could be produced by them with less labour; the moveable card board having a handle at each end was brought down upon and gently passed over the cotton on the lower card, which had its wire teeth bent in the opposite direction, the weight then raised it up again, and the operation was repeated. It also gave a longer sliver when taken off by the needlestick.

"The important invention of the carding cylinder has been ascribed by some authorities to Sir Richard Arkwright, and by others to Lewis Paul. It does not appear, however, that either the one or the other are justly entitled to the merit of being the first who used cylinders to card cotton, but to Daniel Bourn, of Leominster, who took out a patent in May, 1748, which is about seven months prior to Paul's patent in the same year."

Arkwright, however, was the greatest improver of the carding-engine, with respect to which our author observes :—"Great modifications and improvements in the construction of this machine have since taken place, to bring it up to its present comparatively elegant and effective form; but the principle of carding with revolving cylinders clothed with cards working point to point, and the produce doffed in a continuous fleece, by the ingenious contrivance of the doffer and stripping comb, remains essentially the same as established by Arkwright, and probably will do so, like a fixed law, for an indefinite period."

The single roller carding-engine, of which we give a diagram (fig. 69, page 40) is a great favourite among cotton-spinners. Mr. Leigh, after fully describing it, dwells upon its advantages and disadvantages in the following terms :—

"The above form of carding engine has, for a long time, been very popular, and is in extensive use, especially for the lower numbers of yarn.

"The theory of its advocates is plausible. It is alleged to be simple, easily managed, and readily set. Another favourable point is one which is unanswerable in argument, as a principle, viz., that clean wire is always coming up as the rollers revolve and are stripped by the clearers. Again, unlike flats, the rollers do not require perpetual stripping by hand, and they are capable of doing more work than can be got through hand-stripped flats. So far so good, and this card appears on the surface as if it would hold its own triumphantly against innovation, especially for low numbers.

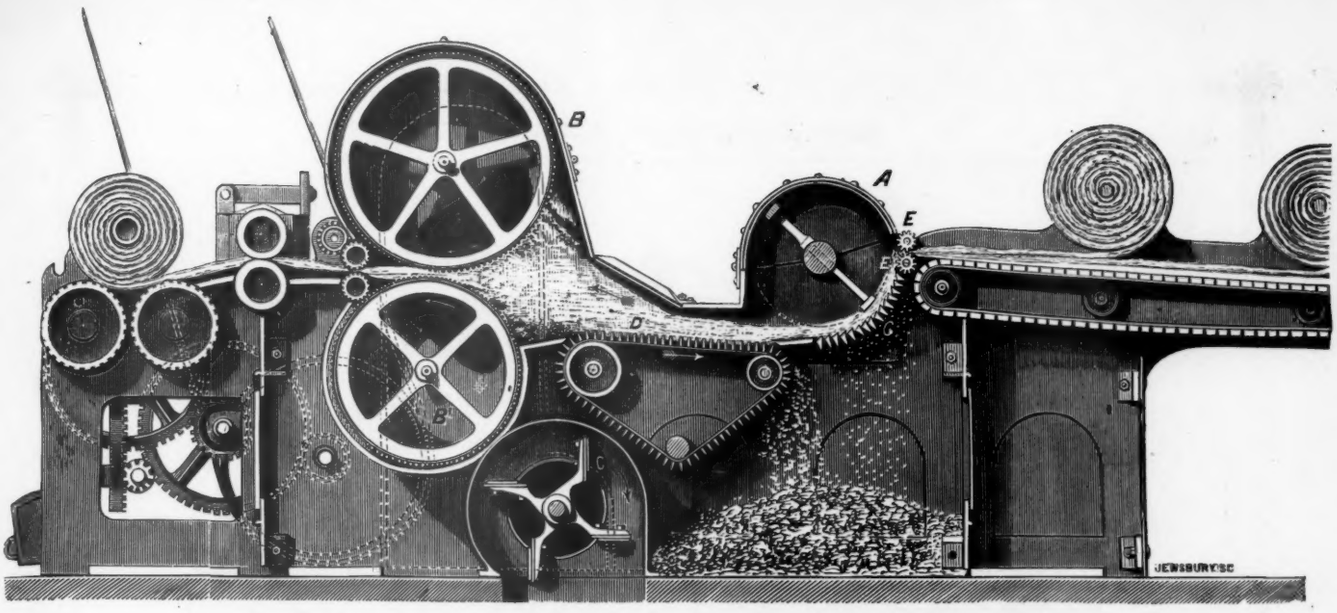


FIG. 52.—SECTION OF SINGLE-BEATER FINISHER LAP MACHINE ON CRIGHTON'S PRINCIPLE.

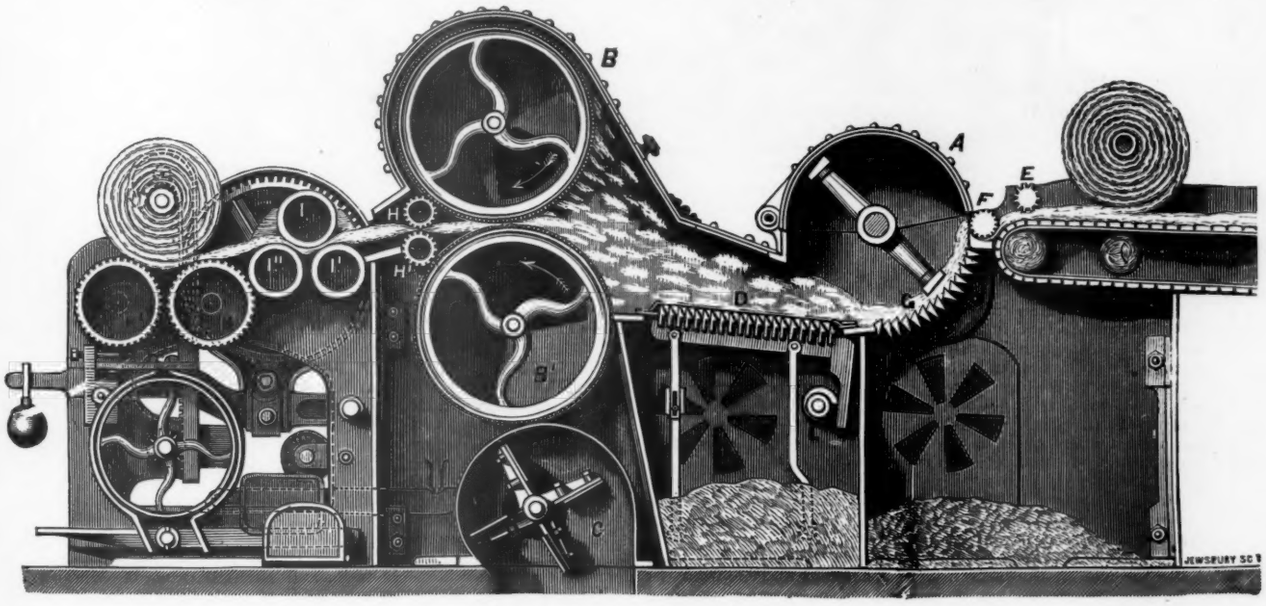


FIG. 54. (Scale $\frac{3}{4}$ inch = 1 foot.)

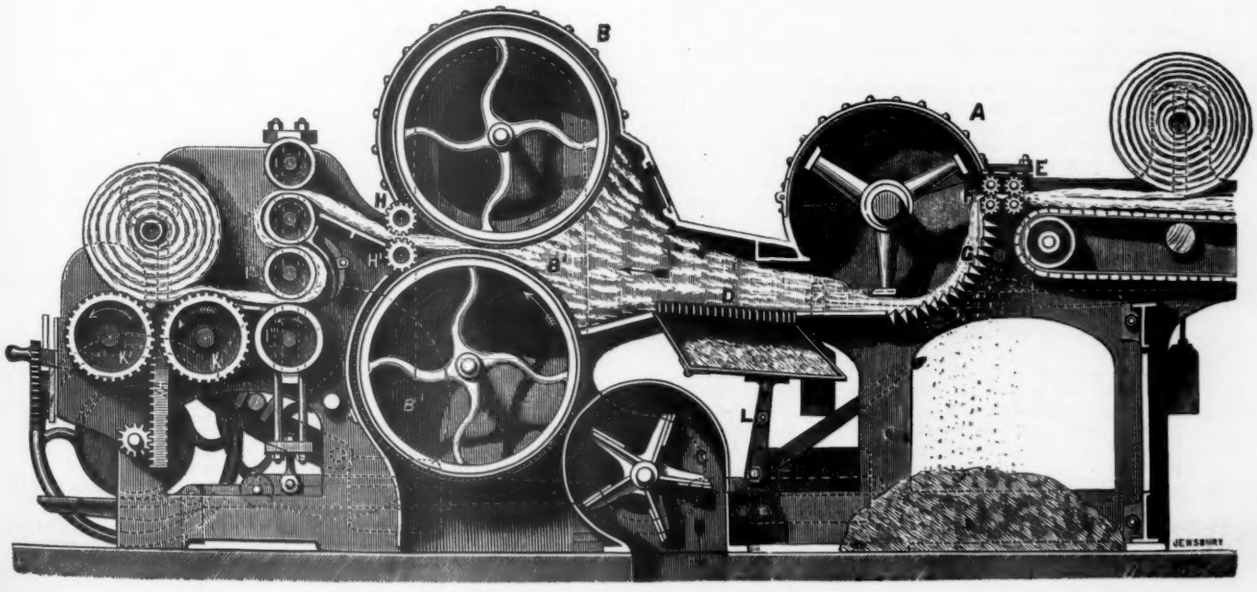


FIG. 55.—FINISHING LAP MACHINE. (Scale $\frac{3}{4}$ inch = 1 foot.)

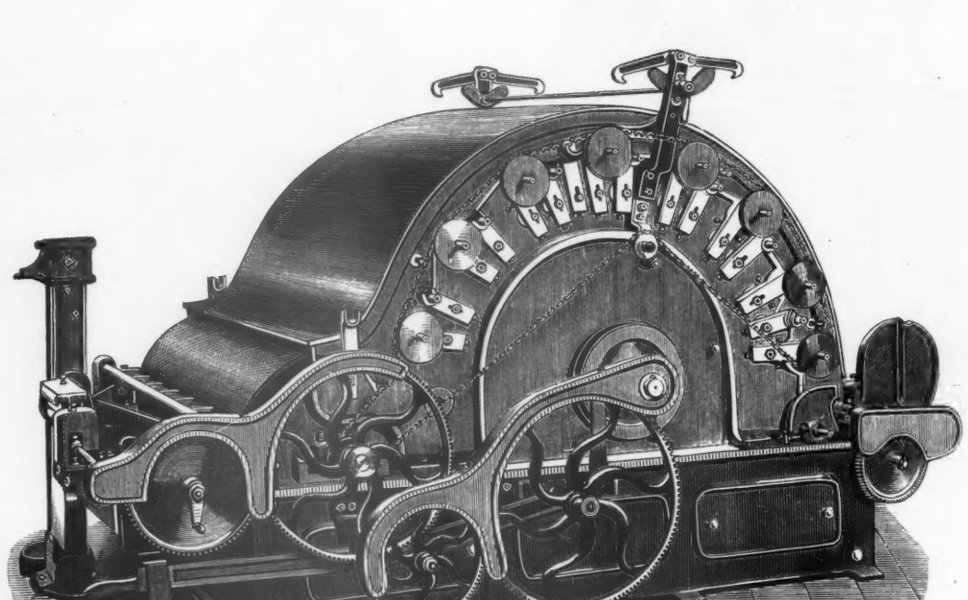


Fig. 69. SINGLE ROLLER CARDING MACHINE.

"After giving this plan of card full credit for its good qualities, in fairness its defects must be exposed.

"Firstly, touching labour, it is found in practice that the saving is more imaginary than real, inasmuch as the rollers and clearers require to be frequently stripped out by hand; likewise, to be kept in good working order, must be often ground up and brushed out. For this purpose a card has to be stopped and have the rollers taken out and carried away to the grinding room, requiring two persons to lift them in and out.

"Secondly, in carrying them about for this object, they very soon get damaged by the wire being crushed down at the ends, which is productive of great mischief, as the card then turns out a ragged and neppy selvage.

"Thirdly, they require lumbering covers to box them up (over the top and at the ends) which want lifting up every time the cylinder is stripped out or ground, and much waste is made, after all, by cotton gathering about and lapping round the roller ends.

"Fourthly, although clean wire is always presenting itself to the cylinder as the rollers slowly revolve, yet this wire is not in the best position for carding and stretching out the fibres of the cotton, neither are there many points to operate upon the cotton passing through.

"Now as the periphery of the cylinder forms a circular line and that of the carding roller another, two circles can only touch at one minute point, and as the wire teeth of a carding roller stand in an almost vertical position to the cylinder, the cotton fibres have a tendency to curl up from such action, hence the work from roller cards is much more suitable for weft than warp, for low numbers rather than high, or even medium counts.

"Fifthly, the quality of the work as regards cleanliness and smoothness is necessarily inferior to flat carding, as the latter takes out more dirt and much of the little white nep, so difficult to remove.

"Notwithstanding these defects, this is a popular card, and many spinners will not look at anything else. It is rough and ready, therefore will always find advocates, especially as the majority of carders have been trained to it. If some simple plan of roller card could be devised by which the rollers could be kept clean and ground in their places, so as to save the labour and rough usage incident to their frequent removal for this purpose, it would not only be very desirable, but would give a finish to this form of card which would greatly increase its popularity."

In 1837, Thomas Birch of Manchester, took out a patent for another form of roller card, the improvements in which enabled him to strip two dirt rollers by combs.

"One of these rollers," says Mr. Leigh, "was placed under the licker-in, and the other over it. In this engine the clearers were placed behind the carding rollers, instead of in front of them, which arrangement saved considerable space on the upper surface of the cylinder, and passed the cotton forward without being turned over and over again. The space saved allowed of one or two more carding-rollers, as both rollers and clearers could be placed close together, which cannot be done in the general way when the clearers are in front of the rollers, on account of the space required for clearance."

Mr. Leigh goes on to remark:—

"There are some very good points about this engine which have been known to work well; and had it been made when first brought out in the style in which it could be constructed now, it would have maintained a lasting position. The principle of setting a dirt roller up to the licker-in is not bad, as by taking much of the heavy motes and dirt away at first, the cylinder cards are saved and cleaner work produced; but it also takes out some good cotton, which may be thought objectionable, and is so to a certain extent; but it is not all lost, as the waste can either be used up again or will fetch its full value for coarse spinning. The dirt roller above the licker-in is a very common thing in roller engines, sometimes being stripped by a comb and sometimes by a hand card. The plan of having the clearers behind the rollers works decidedly well, and is believed to make smoother carding; the cotton being passed straight on from roller to roller without being turned over, as it is when the clearer is in front. More carding rollers, also, can be got on an engine so constructed. The clearers are of solid wrought iron, about $1\frac{1}{4}$-inch diameter without cards, and when clothed should be about $1\frac{7}{8}$ inches only, being clothed with very fine fillet (about 140's) of short cut wire, and more 'keened' in the bend than usual."

With respect to the speed of rollers and clearers our author makes the following excellent practical remarks and recommendations:—

"It will be noticed that in the last-named carding engine the clearers are very small in diameter, and it will naturally be supposed that they ought to go very fast. This is a mistake. True, they would have to go very fast indeed if worked at a surface speed of 400 feet per minute, which is commonly, but very erroneously, put down by most machine makers as the proper speed of a clearer, whilst the speed of a carding roller, which

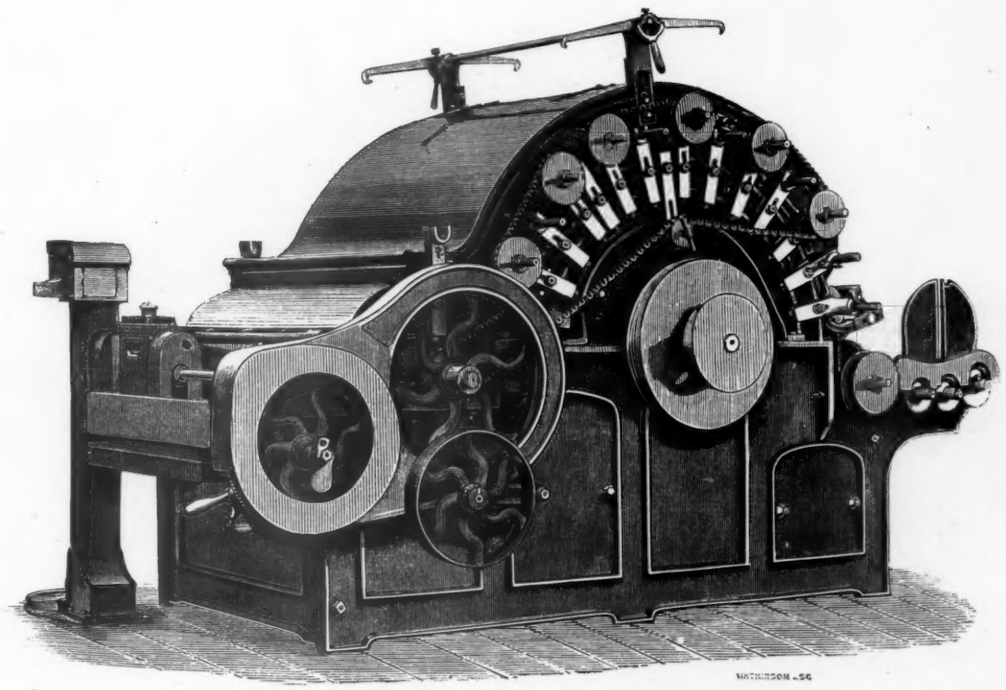


Fig. 82.—CARDING ENGINE WITH THE MASON BEND.

the clearer has to strip, is only moving at the surface speed of 20 feet.

"Now all that the clearer has got to do is simply to take the cotton from the roller and put it on the cylinder again, which can be accomplished quite as well if the clearer has a surface speed of only 25 feet per minute, as if it runs 400 feet in that time; therefore all the power required to turn the clearers twenty times faster than necessary is entirely lost, together with the extra oil, wear and tear, &c. Prejudiced old carders have of course a reason for running the clearers so fast, which it will not be difficult to show is founded on error. It has been asserted that if the clearers go fast they will strike the motes down into the wire of the main cylinder.

"This is plainly an error, because to do that they would require to run at the same surface speed as the cylinder itself, which would be utterly impracticable, and, were it possible, the cylinder would not then strip the clearers. If all the clearers in a roller carding mill were slowered to about one-twentieth their present speed, a visible saving of fuel would at once be effected, with less hurry and greater cleanliness about the engine, without any deterioration whatever to the quality of the work, but rather the contrary. The clearers would then go about 16 revolutions per minute, instead of 320 revolutions, as at present, which would be equal to a saving of about one-half the entire power which a roller carding engine takes. Respecting the surface speed of 20 feet per minute, which is put down as proper for rollers to run, it may be observed that the speed of a carding roller or worker is not absolute. It may be varied 50 per cent. or more either way without making any perceptible difference in the carding. This arises from the circumstance that a roller does not fill with cotton to an injurious extent in a moment, and as the point of contact with the cylinder is so very fine, very little speed is really necessary to bring up clean wire sufficient for beneficial action. Some spinners, on the plausible theory that the more clean wire brought into action by the carding rollers the better, have increased the speed of their rollers to 40 or 50 feet of surface speed per minute, without the slightest beneficial result; indeed, if any difference can be observed, the work looks rather rougher, which may arise from the fact that a roller at so quick a speed has not time to fill; therefore it only brings up a very thin film of cotton for the clearer to strip and convey back to the cylinder, so thin that it can scarcely take hold of it, and the straggling cotton fibres being no support to each other, get curled up in different directions; therefore the extra power required to drive the rollers faster is not only lost, but the work is less smoothly done.

"In some cases two rollers are stripped by one clearer, the latter being placed between them. This is not a good plan; there is no particular objection to the clearer stripping the two, but because it involves the two rollers being set up to the clearer, and if this be not done accurately, the rollers get out of parallel with the cylinder, which is a great evil."

With respect to roller engine bends he remarks:—

"Machinists have generally their own crotchets about engine bends and the mode of setting rollers and clearers. If illustrations were given of all the different methods that have been devised for this object, they would extend over many pages, and distract the student's judgment without answering any good purpose; therefore it is thought better to lay down an absolute rule, which must be attended to in the manufacture of all engine bends, whether for rollers or flats, otherwise bad carding will result. Whatever form of bend be adopted, it is of the utmost importance that the carding rollers or flats be set *exactly* parallel with the cylinder, and that the movement downward as the wire wears be in a *direct line*, converging to the centre of the cylinder on both sides of the engine. This is a point which is sometimes neglected by machinists, even where they have proper tools to do the work, and the result is unsatisfactory carding, arising from a cause which is not suspected, and which might just as well have been made right as otherwise.

"This accurate movement of the rollers so as to converge to the centre of the main cylinder being assured, the simpler and neater the pedestals and other fixings are made the better, it being quite unnecessary to resort to complications and unsightly mechanism to effect this object with precision."

Various other carding engines are mentioned by Mr. Leigh in this part of his work, with accurate descriptions of the properties of each, pointing out their respective merits, and showing in what respects they come short of the practical results proposed to be attained by them. We give above a diagram (fig. 82) of a carding-engine with the Mason bend.

Mr. Leigh is himself the patentee of a "self-stripping carding engine," of considerable repute among manufacturers, which, after undergoing successive improvements, appears before us in the diagram (fig. 111) on the next page.

Our author, while himself an inventor, shows the extreme of

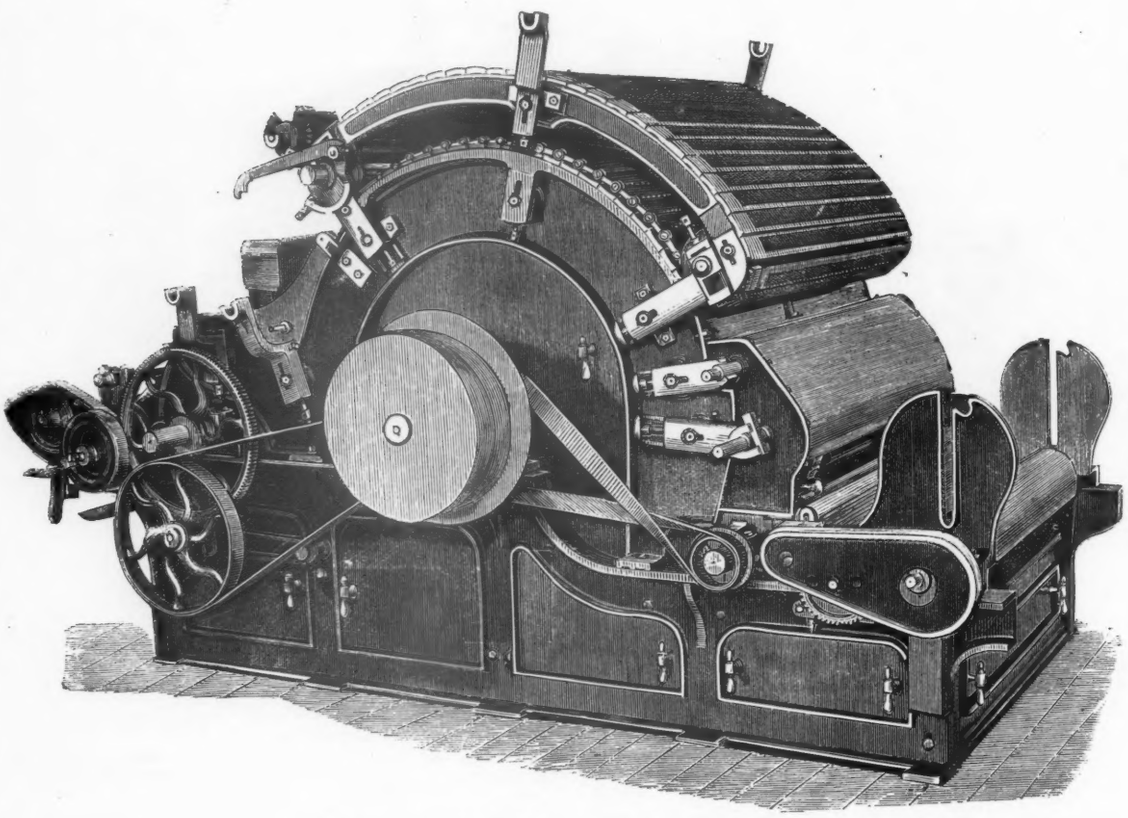


Fig. 111.—LEIGH'S SELF-STRIPPING CARDING ENGINE.

impartiality in the high terms of praise in which he speaks of Wellman's "self-stripping card," of which we give a diagram (fig. 115) on page 43.

Mr. George Wellman was an American inventor, of Lowell, in the United States, and his machine met with so much favour, not only in the United States but in Great Britain, that Mr. Leigh has thought it due to him to set forth the inventor's specification in full. Almost simultaneously with the Wellman card two other cards were introduced, namely, that of Robert Wilkinson, and that of Bayley and Quarmby. "After a fair and spirited contest conducted by the patrons of the Wilkinson card, in two separate mills, it was eventually abandoned in favour of the Leigh. The card produced at Messrs. Bayley's mill did not work well in practice; and Mr. Bayley, who was an intelligent and extensive manufacturer, had too much good sense to push it into public use after he became convinced of its defects. After this another impulse was given to the Leigh card; the Wellman card also maintaining its ground, some spinners preferring the one, some the other, but both were extensively adopted with satisfactory results." In such modest terms does the author speak of his own invention.

Before concluding this part of the subject we call attention to the author's general observations on carding, which are full of sound sense and philosophy, indicating a mind that looks forward to the future triumphs of science in this department of manufacture: "Nil actum reputans dum quid superesset agendum." Mr. Leigh's concluding observations are as follows:—

"Closing the important subject of the carding engine, and taking a retrospective view of what has been accomplished during the first century of its existence, it must be admitted that considerable progress has been made, and that the whole subject seems to be thoroughly understood; but nevertheless it is still very far from approaching not only what may be desired, but to what is really practicable and within the reach of advanced mechanism.

"It is not in the nature of things that any art, Minerva-like, should at once attain perfection; only by patient toiling onward, step by step, can one grasp what seems by the light of this day to be the limit of human attainment.

"Ere another century pass away—nay probably much less, for improvements are now accelerated—and the best examples of the present carding engine will seem crude and ponderous. It requires neither the foresight of a prophet, nor the penetration of a philosopher, to discern its still existing imperfections, but only calm reflection, which whispers that hundreds of tons of coal are daily wasted in turning superfluous matter, giving motion to clumsy, complex, and unnecessary gearing. True it is that hand-stripping has been superseded, but not in that perfectly satisfactory manner which is desirable, for the best examples given in these pages are but crude and imperfect. Then, again, attention may be called to the futile attempts made to strip the cylinder running, which is not only very desirable, but believed to be quite within the reach of skill, and of easy accomplishment.

"There is also, to some extent, a waste of capital in the construction of carding engines; they ought to cost less for the effect produced. Of late it has become the custom to have the main cylinder of large diameter, from 45 in. up to 60 in., which increases the expense of a carding engine very materially, and absorbs more power in driving it.

"If judiciously constructed, as much wire can be got upon a carding engine with a 40 in. diameter cylinder as it will be profitable for the cotton to pass over at one operation, and, besides costing less, the low built engine has many conveniences about it that are very desirable.

"Again, the setting up of the surfaces first on one side of the engine then on the other, one side of a roller or flat at a time, bit by bit, the carder often forgetting which side he set last in a room of carding engines, is very imperfect, causing both trouble and mischief. 'Leigh's flexible bend,' although not absolutely exact, was nevertheless the first step in the right direction, and dispensed with very many setting screws. Ugly bolts, innumerable and unnecessary set screws, still exist in the best examples of modern carding engines, baffling and perplexing the most

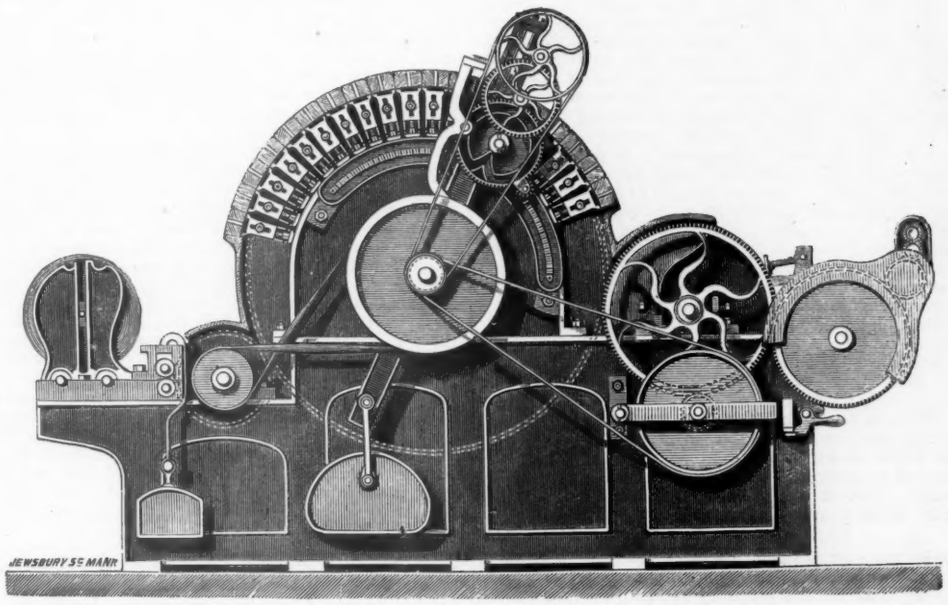


Fig. 115.—WELLMAN'S SELF-STRIPPING CARDING ENGINE.

careful carder. A more correct and efficient system of setting is clearly indicated, by which all the working surfaces of the cards can be made to converge steadily and with mechanical precision, without derangement of parallel, towards the centre of the cylinder, when from the wear of the wire it becomes necessary to set them closer."

Of the numerous other processes connected with the modern science of cotton spinning, we have left ourselves very little room to speak. All are amply illustrated both by pen and diagram in the work before us. Let us barely call attention to the writer's remarks on the "combing machine," the most striking and romantically successful of inventions that have been made in cotton spinning, and of which Joseph Imbs's patent is the latest exemplification and improvement; also to the "drawing frame," and the various machines invented for the process of "slubbing." In connection with this operation of "slubbing," the following machines have been from time to time invented, viz.: the "lantern or can-slubbing frame," the "bobbin and fly frame," the modern "slubbing frame," the "intermediate frame," the "roving frame," the "fine roving or jack frame," the "Tatham and Cheetham's can slubbing frame," "Barlow and Taylor's patent duplex slubbing frame," "Leigh's loose-boss top roller," the "dyer's frame," the "Abegg roving frame," and the "eclipse roving frame." In sooth a goodly company of inventions to facilitate only a single process in the cotton manufacture! And what mental toil and anxiety must there have been, what planning and contriving, hopes crushed, yet again springing up in the inventor's mind, ere these several machines became perfected and fitted for the cotton-spinners' use! Think again, what money must have been often expended in seeking to bring the invention to a successful issue, (Mr. Leigh's invention, just mentioned, cost him £1,300), and the mortification that must ensue, when, after being accepted by the public, and the inventor believes he is about to realize a fortune by it, suddenly it comes to be superseded by a *better article!* What boldness! What madness! Many will feel tempted to exclaim, "Oh! who would be an inventor?" And yet it is by such boldness, or madness—call it what you will—we prefer to call it indomitable perseverance in the pursuit of practical science—that the world progresses, and the material happiness of millions is increased!

Mr. Leigh has some excellent remarks to make on the general *management of frames*, from which we select the following:—

"All slubbing, intermediate, and roving frames should have their rollers taken out, the bottom rollers scoured, the squares oiled, and the other working parts of the frames taken to pieces and thoroughly cleaned, once every six weeks; drawing frames once a month or oftener. This is called scouring through, and should on no account be neglected.

"Draughts must be apportioned in these different frames according to circumstances, ever bearing in mind that a better quality of work is produced with a fine roving than with a thick one; but a fine roving cannot be produced for any definite object without a sufficient number of spindles, or, what is equivalent, good work, so that the frames can be kept constantly running.

"A good manager will, by keeping his cards in order and his frames clean, produce a sufficient quantity of a 5-hank roving to keep his spinning going from a given number of frames, whilst a slovenly manager could not get more than a 4-hank roving in the same quantity, the cotton, mixing, &c., being the same. Now the difference in the spinning and quality of yarn produced would be so great, that where the slovenly manager only made ends meet, the good manager would make a handsome profit.

"It is a bad thing to keep constantly changing draught pinions, or ratchet wheels in frames. Alterations, when required, should be made before the cotton enters the frames.

"All the slubbing frames, doing the same kind of work, when first started should be adjusted to knock off at the same length, have the same ratchet wheel and change pinions, so that the bobbins, if mixed, will come off at the same time. If this is properly attended to, half bobbins and whole bobbins can work together in the intermediate frames, which should, in their turn, be similarly adjusted to allow of both running through together in the roving frames. By careful attention to this point the work will be much more regular.

"A great improvement was made in the lift-gear of slubbing and roving frames about thirty-eight years ago, by the application of screws to the lifting rails, instead of the racks and pinions, which cause the rails to dwell a little at each change, by reason of the backlash in changing with so slow a motion. However perfect the rack and pinion gear may be made, the motion is so slow that a little dwelling of the rail takes place at every reverse of motion, which is fraught with great evil, as it stretches the work by winding on tighter at the moment, and increasing the diameter of the bobbin a little at the ends. By the application of screws, the rail rests with a portion of its weight on the threads, and the instant the reverse or change takes place, down or up (as the case may be) goes the rail. This improvement was hailed by the trade as a very beneficial one, and for a short period it was very popular; but alas for human foresight and prejudice! unfortunately these lifting screws were made of wrought iron, and the bushes of brass, which soon wore out, and consequently got cried down; therefore this beautiful improvement was at once thoughtlessly abandoned.

"A spinner had at this time one of his slubbing frames lifted by screws, and noticed his tenters frequently quarrelling about the bobbins. Whenever a set was doffed there was a rush to get hold of them, simply because they worked so much better

than the others. This he distinctly ascertained arose from the fact that they were not stretched at the ends, like the others. Subsequently, having a new mill to fill, he was determined to have all his frames with screws, very much against the advice of the eminent machine-making firm who had abandoned the principle on account of its excessive wear and tear. The spinner nevertheless persisted, but had both the screws and the bushes made of *cast iron;* and instead of allowing the whole weight of the lifting rail to rest upon the thread of the screws, he had it partially balanced, leaving only a preponderance of weight upon them. For twenty-five years these frames were worked, and the screws seemed to be quite as good at the last as they were at first, never having cost a penny in repair during the whole time! This added another to the many previous proofs a long experience had given him of the value of cast-iron surfaces working together, care being taken to oil them well at first until the metal is saturated with oil, which, from its uniformly porous nature, it takes in like a sponge, and afterwards attains a high polish like glass, becoming almost as hard and durable.

"Many good inventions get unthinkingly condemned through some little blunder or oversight having been made on their introduction. It has been thus with this valuable invention of the screw lift: it is hoped, however, that this really good thing may some day be revived."

We next come to our author's account of the processes properly called "spinning." Of early spinning machines the first for which a patent was taken out was by Lewis Paul, of Birmingham, in the year 1738, the specification of which runs thus:—

"The said machine, engine, or invention will spin wool or cotton into thread, yarn or worsted, which, before it is placed therein, must be first prepared in manner following (to wit): All these sorts of wooll or cotton which it is necessary to card must have each cardfull, batt, or roll joyned together, so as to make the mass become a kind of rope or thread of raw wooll. In that sort of wool which it is necessary to comb, commonly called jarsey, a strict regard must be had to make the slivers of an equal thickness from end to end. The wool or cotton being thus prepared, one end of the mass, rope, thread, or sliver is put betwixt a pair of rowlers, cillinders, or cones, or some such movements, which being turned round by their motion, draws in the raw mass of wooll or cotton to be spun, in proportion to the velocity given to such rowlers, cillinders, or cones. As the prepared mass passes regularly through or betwixt these rowlers, cillinders, or cones, a succession of other rowlers, cillinders, or cones, *moving proportionably faster than the first*, draw the rope, thread, or sliver into any degree of fineness which may be required. Sometimes these successive rowlers, cillinders, or cones (but not the first) have another rotation besides that which diminishes the thread, yarn, or worsted (viz.), that they give it a small degree of twist betwixt each pair by means of the thread itself passing through the axis and centre of that rotation. In some other cases only the first pair of rowlers, cillinders, or cones are used, and then the bobbyn, spole, or quill, upon which the thread, yarn, or worsted is spun, is so contrived as to draw faster than the first rowlers, cillinders, or cones, give, and in such proportion as the first mass, rope, or sliver is proposed to be diminished.—In witness whereof, &c. "LEWIS PAUL.

"Witnesses: SAML. GUY, JOHN WYATT."

Mr. Leigh remarks upon this:—

"It will be seen from the wording of Paul's specification that he clearly conceived the idea of drawing out the fibres of cotton by a succession of pairs of rollers, but he shows no drawings to indicate by what mechanism it was to be done; and in the latter part of his specification he seems to have a confused notion of *giving a little twist* between some of the pairs of rollers, when he says that they have another rotation besides that which diminished the thread, by means of which the '*thread itself passes through the axis and centre of that rotation.*' It would have been better for Paul's reputation if he had left the latter part of his specification out altogether. No wonder that he found it difficult to show drawings of what he meant, and therefore he omitted them altogether. This machine, from its description, should rather have been termed a 'drawing' than a 'spinning' frame.

"During the time that Paul was engaged upon this machine, he was connected in partnership with John Wyatt, who signed his specification as a witness. Although the patent was taken out in Paul's name, Wyatt claims to have been the principal agent in compiling the machine, and says that so early as 1733 he made a model two feet square, which had two cylinders, through which he passed wool that had been carded in the common way, 'from whence the bobbin drew it by means of the twist.' He and his friends further say that he let this invention slumber for some years for want of means to prosecute it, and that he ultimately showed it to Paul, who promised to find capital and assist him in getting it out. How far Wyatt's statement is true it is now impossible to say; but according to Wyatt's own account he constantly lived in London about the time that Paul was beginning to work his machine, and acted as salesman for the concern, leaving Paul in management of the machinery at Birmingham.

"It is impossible to say what kind of a machine it was that Paul and Wyatt brought out, but certain it is that they succeeded in making some kind of yarn about the year 1741, a hank of which is said to be still extant, but, nevertheless, the concern was unfortunate, and was broken up in 1743. Subsequently works were established at Northampton, containing 250 spindles, in five frames of 50 spindles each, which were driven by water-power, and employed fifty people altogether. Wyatt, who appears to have been a very intelligent man, wrote a 'Systematic Essay on the Business of Spinning,' in which he fully describes this concern, and says that each frame was reckoned to spin 15 skeins or hanks per day, No. 15 to the lb., and the yarn was supposed to have about 20 twists to the inch. The wages paid weekly amounted to about £2 19*s.* 7*d.*, or say £3. Like its predecessor in Birmingham, this concern became unfortunate, and got into the hands of a Mr. Yeo, a London lawyer, in 1764. The machinery in this mill was probably made upon Paul's latest improvements, for which he took out a patent in 1758, as the frames are said to have had 50 spindles each, the number which Paul shows in the drawings and full description lodged with his specification."

In 1758 Paul took out a second patent for cotton spinning, which, however, proved to be a failure. It was followed in 1767 by the well-known "spinning jenny" of James Hargreaves, of Blackburn, said to have been suggested to him by the accidental overturning of a spinning wheel.

"It will be seen that Hargreaves' method of spinning was totally different from that of Paul; for, instead of rollers, a certain length of the rovings were passed between two pieces of wood, one of which was fixed in a horizontal position, and the other suspended over it, until brought down by the spinner, when the rovings were clasped and held, whilst the carriage or clasp receded from the spindles, thus drawing out the threads while the spindles were revolving rapidly and converting the rovings into yarn; then, by the ingenious contrivances of the faller, backing off and putting up the carriage, the yarn was wound upon the spindles in the form of a cone or cop, after which the operation was repeated until the spindles were full, the *set* was then doffed off, and the cops held together ready for the loom shuttle, or other purposes. Hargreaves produced in this manner yarn without either bobbin or flyer, of a soft and woolly texture, admirably suited for weft.

"Hargreaves' invention came very opportunely, for in consequence of Kay's invention of the fly shuttle about this time, the demand for *weft* so far exceeded the supply, that weavers were often obliged to lose time in search of it, and the poor spinsters were sorely taxed and overworked."

Richard Arkwright, however, was in fact and truth the inventor of the machine, which under whatever modifications or improvements—and they have been numerous—is the basis of the cotton manufacture of Great Britain. Of this extraordinary man the work before us contains an admirable account, but his career is so well known to almost every reader that we need not here dwell upon it. It may not be generally known, however, that among the various schemes that occupied his restless brain was one for buying up all the cotton in the world, and retailing it for his private advantage.

Speaking of "throstle spinning," Mr. Leigh remarks:—

"It is almost impossible for any one, having a mechanical turn of mind, to watch a throstle frame at work without feeling an irresistible desire to experiment upon it; hence it has been the toy of the machinist and plaything of the juvenile spinner." Still no improvement was made in it until the year 1829, when suddenly a remarkable invention called the "Danforth throstle" reached this country from America. The capabilities of this machine were very great, but it had some fatal defects in its construction, which made it lose caste, and eventually led to its entire disuse. It was succeeded by "Gore's patent throstle" in 1831, and by that of Mr. Charles Axton, in 1832. Then came the "Montgomery throstle" also in 1832; "Shaw and Cottam's patent throstle" in 1848; and "Bernhardt's throstle with doffing motion," the date of which is not given.

In "ring-spinning," which was introduced into England from America a few years after the "Danforth throstle," there have also been successive improvements.

We next come to our author's account of the "mule or mule-jenny," which is thus described:—

"The important machine bearing this singular appellation had its origin at Hall-in-the-Wood, a picturesque dwelling near Bolton, and was the invention of Samuel Crompton, the only son of Mr. George Crompton, who cultivated a small farm at Firwood, where Samuel was born December 23rd, 1753.

"Shortly after Mr. George Crompton's removal to the ancient house called Hall-in-the-Wood he died, leaving Samuel and his sister to the care of their mother, who continued the occupation of farming, and devoted her spare time to carding and weaving with such domestic machinery as then existed. The family had one of Hargreaves' jennies with eight spindles, upon which Samuel worked from the age of sixteen to twenty-one, when he commenced experimenting with the machine. After many failures, these experiments culminated in 1779 in a movable carriage on which his spindles were erected, and one pair of rollers through which the cotton sliver, or rove, was drawn. Later on, two pairs of wood rollers, covered with sheepskin, were used, having iron axles, with square ends, upon which pulleys were fixed of different sizes, so that one pair would go faster than the other, and thus draw out, or elongate, the sliver as the carriage and spindles receded, thus giving twist to the yarn. He finally put dents of brass reed wire into his under rollers, and thus obtained a fluted roller. The faller, as in Hargreaves' jenny, was fixed to the carriage, and now moved with it, so as to be worked by the left hand. In 1780, after bringing his machine to a practical and profitable state, Crompton married, after which he and his wife worked the spinning wheel, or *muslin wheel*, as it was sometimes called, in a cottage adjoining his mother's house, where he had taken up his abode.

"By the help of this machine he could spin both finer and better yarn than his competitors, for which he obtained his own price, and thus worked on in secret. The demand for Crompton's fine yarns at length became so urgent, and the advantage he possessed over his competitors became so marked, that public curiosity was aroused to such an extent, that the quiet spot of Hall-in-the-Wood was invaded, and all sorts of impertinent stratagems were employed to get at his secret. The annoyance to which he became subject at length was so intolerable, that concealment was no longer possible; and having no money to patent his invention, he yielded to the liberal, but treacherous promises of neighbouring manufacturers to divulge his secret, on the assurance that they would get up a handsome subscription to reward him. All they got for him was £106!—some refusing to pay their guinea or half-guinea, for which they had put down their names, denouncing him as an impostor! Crompton's subsequent life was of a chequered description, notwithstanding that his invention turned out to be of so important a character, giving a vast impulse to the cotton trade and employment to hundreds of thousands of workpeople.

"Application was at length made to Government on his behalf, and Parliament granted him a pitiful allowance of £5,000, which his friends expected would have been at least £50,000 considering the vast benefit he had conferred on the nation. His fellow-townsmen subscribed again for him in his latter days, and bought him an annuity of £63. He died on the 22nd June, 1827; and in thirty years afterwards a large bronze statue was erected to his memory in one of the public squares of Bolton."

There have been various modifications of the "mule or mule-jenny," since that invented by Crompton, but we leave these in order to come to the important subject of "steam boilers and steam engines."

It was a fortunate thing for the success of the cotton manufacture in this country that almost simultaneously with the inventions of Arkwright, James Watt invented the steam-engine, in consequence of which the application of steam machinery to the advancement of manufactures of all kinds, that of cotton included, or perhaps we should say, cotton pre-eminently, took possession of every mind. The successive improvements effected called forth the opposition of the operatives—sometimes even of rival manufacturers—the result of which was riots, and the forcible demolition of improved machinery in the various quarters in which it had been called into requisition. Still the genius of inventors and enterprising trade speculators went on, improving and striving to perfect what had been so happily begun. Thus it was with steam machinery, as applied to cotton-spinning. Every one is acquainted with the origin of the steam-engine, and most persons know of the principal improvements made in it. We shall, therefore, content ourselves with quoting some of our author's remarks on the latest of these improvements.

"After having generated steam in the most economical manner, the next question is, 'How to use it to the best advantage?'

"The nature and properties of steam are now well understood. Steam is no longer used in engines merely as a condensing medium, but in the best engines its high-pressure properties are first turned to account by expansion, and then it is condensed to form a vacuum. This double application, combined with higher piston speed, has completely upset the old method of estimating the power of an engine, as settled by Watt; and engineers are suggesting other modes as a standard of power, seeing that in actual practice the best made engines, worked expansively at a quick speed, give off an indicated power seven or eight times that of the nominal, by the old rule. Nevertheless no more convenient rule can be devised for universal application, to estimate cost, than that established by Watt; for speed has nothing to do with the cost, neither has the pressure of the steam. It is only a question of quality of construction; and a few extras, such as expansion valves, &c., or a guarantee given that under certain conditions of piston speed and steam pressure in boiler, the engine will indicate so many horses' power above the nominal.

"A ready method of estimating the nominal power of an engine, according to Watt, is as follows: viz.,—

If the steam cylinder of a condensing engine be 30 in. in diam., it is	30 H.P.
Therefore, if doubled to 60 in. diam., it would have four times the area, and be	120 H.P.
If doubled again to 120 in. diam., it would have sixteen times the area, and be	480 H.P.
Going downwards from 30 in. diam., to 15 in., we get	7½ H.P.
If the cylinder is increased one-half larger in diameter, the power is doubled; thus, if 30 in. be 30 horse-power, 45 in. will be	60 H.P.

And so on, by adding or diminishing, any intermediate power may be mentally arrived at without employing a formidable array of figures.

"Assuming that quick running, direct-acting engines will for the future be exclusively employed in driving cotton machinery, and that the steam used will always be at high pressure, it is an open question whether to use one cylinder or two to each engine. Some engineers prefer to expand the steam in one cylinder by an early cut off, and others recommend two. When two engines are connected together and run at a high speed, one cylinder has the advantage of greater simplicity and answers best for cotton mills up to about 60 lbs. pressure on the square inch. When steam is used at a higher pressure—say from 60 lbs. to 150 lbs. on the square inch—it is better to compound the engines by having a high-pressure cylinder of smaller dimensions to take the steam first and discharge it into a larger cylinder, through a vessel where it can be re-heated before passing into the larger cylinder. This re-heating may be accomplished by the steam as it comes from the boiler to the high-pressure cylinder through a tubular vessel.

"It is a fact that expansion produces cold; and unless steam be superheated before it leaves the boiler or reaches the cylinder, it loses much more of its pressure than it otherwise would by the first expansion, as it becomes then too moist. The superheating takes up this moisture, and to some extent prevents it losing pressure. When only one cylinder is used to each engine and the cut off is made early—say at one-tenth of the stroke—the steam requires rather more superheating, as there is some chill produced by its being open to the condenser alternately at each stroke, the loss from which is greater in a single cylinder engine, because the temperature of the steam at full pressure is much higher than it would be if already expanded in a high-pressure cylinder, and the shock on the piston is much greater at the commencement of the stroke. This shock is best taken up by a heavy piston and connecting rod, which acts as a sort of anvil for the steam to strike against, and prevents to a considerable extent the thump upon the crank pin."

On the subject of "shafting," solid and hollow couplings, bearings, and steps, Mr. Leigh has a chapter.

On "water-power," Mr. Leigh has a section from which we give the following extract:—

"In treating upon this subject it is not intended to enter into detail, or to repeat what has been so ably written by Sir William Fairbairn and others who have made water power a special study, but simply to point out that, except in some peculiar situations where the fall is under six feet, all the experiments which have been tried to utilize ordinary waterfalls to the greatest advantage and economy have led to the conclusion that the breast wheel, with ventilated buckets, and the turbine, give the best results. For moderate falls and slow speeds it is doubtful whether any known machine will excel the properly constructed breast wheel in simplicity and durability; but for driving cotton machinery, which requires a rapid speed, the turbine is undoubtedly the best, because it takes its motion from the bottom of the fall, where the speed of the water is quickest, whilst the breast wheel takes its motion from the top of the fall, where the speed of the falling body is slowest. All bodies fall with a constantly accelerated speed, and, if unimpeded, pass through 16 ft. of space in the first second of time, 48 ft. more in the next second, and 80 ft. in the third, and so on, continually increasing

their speed by 32 ft. every second; therefore, the higher the fall the less costly is the turbine for any given power, inversely to that of the water wheel, which is more costly for high falls and cheaper for low falls than the turbine. But the turbine is better from the fact that it starts off at a higher velocity than the water wheel, therefore requires less gearing to get up the necessary speed of shafting for cotton mills. Suppose the fall to be 16 ft., and the water be conducted down a pipe that length, as in the case of the turbine, the water at the bottom of the pipe presses with a force equal to about 7 lb. to the square inch, and would gush out of an orifice at a speed of 32 ft. per second of time, because, although it only falls 16 ft. during the first second, it has attained a speed of 32 ft. per second by the time it has reached the first 16 ft. If it could continue its descent, it would attain a speed of 64 ft. at the end of the next second, and would reach a speed of 96 ft. at the end of the third second. Now, recurring to the fall of 16 ft. and the pressure of the water at that depth, it is evident that the periphery of a turbine wheel can go three or four times faster than that of a water wheel, that acts altogether by gravitation, and the turbine both by gravitation and impact. The periphery of a breast water wheel can only go at a maximum speed of about 5 ft. per second with advantage, whatever be the height of the fall. If it goes faster it overruns the natural gravitation of the water and wastes the power, therefore it is only properly adapted for slow speeds. Quick speeds can be only got from it by a multiplication of heavy gearing, occasioning a loss both of capital and power."

We could have wished to find space for the author's remarks on what he calls the "romance of water-power." But, however well expressed we must leave these out, steam-power having almost universally superseded water-power in this country. We prefer calling attention to the following practical remarks on the "general management of cotton mills":—

"The author has not considered it necessary to produce the figures and calculations so usual in works of this character, for it has been assumed that every one taking charge of machinery, or the management of a cotton mill, understands common arithmetic, and the manner of ascertaining the speed of any shaft, cylinder, or roller, by multiplying the *driving* wheels or pulleys together, and the *driven* wheels also, and then dividing the one product by the other. Beyond this, and a knowledge of the rule of three, there is really very little more required in the way of figures to enable one to manage a cotton mill; but a knowledge superior to that of the mere school-boy is required to make an expert cotton spinner.

"The manager should be thoroughly versed in mechanics, familiar with the fibres and qualities of the different cottons, see that everything about the premises is kept clean and orderly, the frames regularly scoured through, the drawing frames at least once a month, the slubbing and roving frames, also the mules and throstles once in three months, when the rollers should be taken out, the flutes scoured and the squares oiled, all the studs and bearings at the same time thoroughly cleaned and oiled with good neatsfoot oil. There should be store-rooms, in which a constant supply of consumable articles are kept, always ready to hand, and duplicates of all parts of the machinery liable to break or wear out. The mechanics should work to stock the store-room, keeping up a supply of the various things given out to the overlookers for consumption, so that if anything breaks or requires repair, no time is lost in the stoppage of the machines. Everything should be done with forethought and anticipation, so that the weekly production throughout the year may be kept steadily up to the maximum point. Weekly, if not daily, indications should be taken of the steam-engines, and a proper register kept of the consumption of coals, oil, tallow, and other articles. When these things are done, and all trade charges, interest of capital, and depreciation tabulated, and the average taken of what they amount to weekly, the cost per pound of any particular number of yarn may be arrived at with tolerable accuracy. If the mill be spinning, say No 30's, the production would be a certain number of pounds weekly, which must be a divisor for all incidental charges reduced to pence and cents, or hundredths of a penny. The wages in like manner. These added to the market price of the day for cotton, and the average loss in waste thereon, the cost of each pound of No. 30's yarn will be found. Having thus ascertained what the concern would produce if spinning 40's, 50's, or any other number, the wages being at a fixed average amount, the cost of any of these numbers, or intermediate numbers, may be tabulated, so that at a glance the spinner may know, when he goes to market, what numbers will pay best to sell, in reference to the price of the raw material.

"It may be here only necessary to remark how important it is to observe a kindly but firm demeanour towards the work-people, the manufacturer doing all in his power to make them happy and contented, avoiding as much as possible all changes of hands, and all unnecessary alterations in machinery.

"As to alterations in counts, they cannot be avoided, and it is indispensable that the manager should be completely master of these things when they do occur."

Further on he tells us "how to make yarn of superlative quality:—

"In establishing a mill, capitalists, not thoroughly conversant with the business, are sometimes at a loss how many frames or carding engines they shall put in for a certain number of mule or throstle spindles, and what hank roving they shall make for the different frames. Examples have already been given of some of the best existing mills, for general purposes, both for fine and coarse spinning, which they cannot do better than imitate. But if a spinner wants to make a very superior quality of yarn, it can only be done by an extra quantity of cards or frames. If rovings are put through an extra frame before being spun and doubled two, three, or four-fold together, a wonderful improvement in the quality of the yarn will be effected. In doubling three or four-fold together, the finishing frames should only have a single row of spindles, or have the bobbins doubled three or four-fold upon a machine with stopping motions, and then the frame might have two rows in the usual way."

Mr. Leigh takes leave of his readers with the following "concluding remarks":—

"In concluding the subject of 'The Science of Modern Cotton Spinning,' and tracing the successive inventions that have led to the important results—political, social, and intellectual—brought about during the last hundred years, it cannot fail to strike the reader that the manufacture of cotton has been the mainspring in effecting the wonderful changes which have taken place. To this manufacture may be traced the general and rapid improvement of the mechanical arts which have developed other important inventions, through the expansion of our commerce, creating a demand for improved transit by land and sea. To this manufacture may be mainly attributed the largely increased revenues of the State, the development of our mines and minerals, and the construction of railways.

"In this manufacture Lancashire has played the most important part. It has, so to speak, clothed the world, covered all known seas with merchant vessels, carried civilization and Christianity amongst the heathen, developed the products of heretofore unknown lands, been foremost in free-trade principles and in knocking off the fetters from the slave, has scattered blessings amongst the destitute, and raised mankind generally to a higher level of social life and happiness. Lancashire has also produced not a few eminent statesmen, philanthropists, and orators; raised the value of our lands, and developed trade and exchanges of commodities everywhere. Lancashire fabrics are now worn by the Arabs of the desert, the negroes of Central Africa, the Hindoos and Chinese of the far East, the Red Indians of the West, and the numerous tribes of Polynesians in the Pacific Ocean. No manufacture of any kind, of any age or country, has ever developed so much original talent and true genius, so much power of invention, mechanical skill, and enormous wealth, as the cotton manufacture of Lancashire. It has drawn out of poverty and obscurity men who have become the controllers of their own destiny, some by life-long struggles, and others by a short but brilliant career;—men who were their own ancestors, as regards family, wealth, and fame;—self-made men, the founders of an original aristocracy, 'cotton lords' and merchant princes, who owed their elevation, not to the favour of the Crown, but to their own brain and sinew and indomitable spirit. No wonder, then, that Lancashire has taken a proud position in the nation, and that her voice is listened to with great respect in the senate. If the nation has been backward in raising sculptured monuments to her eminent mechanicians and sons of toil, the stranger who visits Lancashire has only to look around at the colossal manufactories and palatial warehouses for monuments of their worth.

"In concluding this last number of the 'Science of Modern Cotton Spinning,' the author desires to record his thankfulness for the very gratifying reception his work has met, not only in Great Britain, but also on the Continent of Europe and in America. He regards this favourable reception more as a testimony to its practical character than to any literary merit. Enlarged editions of its parts have been demanded while passing through the press, which have caused some delay from the intended period of publication of the different numbers. The work is for the most part the result of the thinkings and jottings down of a long and varied experience, during which cotton mills have been visited in all parts of the globe except the few in the far East. He lays down his pen not without hope that the comprehensiveness of the numerous details of cotton spinning, in its various branches and operations, as well as the elaborate illustrations of machinery, embracing the most recent improvements and inventions, will render the work full and complete, if not altogether exhaustive, upon the subject of 'The Science of Modern Cotton Spinning.'"

We end as we began, by commending Mr. Leigh's work to the notice of our readers. It is the best work of the kind that has hitherto appeared, and deserves to pass through several editions. Let us only express a regret that in place of the likeness of the author taken from a photograph, in the frontispiece, there was not one given from the excellent portrait painted by Captain Charles Mercier, now in the collection of portraits of inventors at the South Kensington Museum.

ON THE SENSITIVENESS OF SILVER BROMIDE TOWARDS THE SO-CALLED CHEMICALLY INACTIVE COLOURS.

IT is well known that certain colours, as red, yellow, green, have photographically a very feeble reaction, or none at all. It is due to this circumstance, that coloured articles (oil paintings) present such difficulties to photography, and that in taking of portraits a yellow complexion, fair hair, red cheek, coloured dress, appear in an abnormal manner. Light parts, if they possess a yellowish tinge, are shown dark in the photo; dark parts, if they verge on blue, appear light, and it is only through retouches that these drawbacks can be somewhat softened.

This abnormal sensitiveness of photographic plates reveals itself in the most striking manner towards the colours of the spectrum, where an active effect makes itself apparent even beyond the violet, whilst in the visible spectrum it does not reach below the E line in green.

Recent experiments with the bromide of silver have, however, shown that its sensitiveness is capable to descend to red, *i. e.* to a point which until now was photographically dark night.

Professor Vogel read a short time ago a communication on this subject before the German Chemical Society at Berlin, from which we gather the following notes :—

For some time past dry silver bromide plates, manufactured by Wortley in England, had been in the trade, the preparation of which was kept secret. The professor exposed such a plate to the influence of the solar spectrum, and, to his great surprise, found it more sensitive in green (at line E) than in blue (at line F). This phenomenon led him to institute a series of experiments with a view of determining whether this extraordinary sensitiveness was really due to the bromide, or perhaps to another constituent in the plate preparation.

The length of the spectrum with which he operated was 35 millimetres from D to G; the time at which the experiments were carried on was from 11 to 2 o'clock, and only by a cloudless sky; the exposition lasted ten minutes; the development was affected with iron protosulphate. It was soon noticed that the plates were effected from ultra-violet to below the line F; according to the greater or lesser transparency of the atmosphere, this effect reached more or less far below F.

The next fact noticed was that *dry* plates had a more extended sensitiveness than *wet* plates; the latter showed traces of effect as far as the middle between E and D, *i.e.* almost into yellow; the first was affected 2 millimetres beyond D, that is fully down into orange.

Under wet plate is meant a plate which is exposed moist with adhering silver nitrate solution, in which it had been sensitized; the dry plate is freed from such adhering solution through washing, and is then dried before exposure.

The effects on both plates were also qualitatively very different. The wet plate exhibits a very strong effect between G and F (indigo and blue); at F it becomes suddenly feeble, and only a faint trace can be detected beyond E. The dry plate is in lesser degree reacted upon in blue, but the reaction diminishes only gradually, and, as already stated, reaches below D.

Dry silver bromide is consequently more sensitive towards the less refrangible, wet silver bromide towards the more refrangible blue rays of the visible spectrum.

These results, though striking enough, differed therefore from those obtained with Wortley's silver bromide plates, where the sensitiveness diminished from violet towards blue, and increased from blue towards green. An investigation of these plates showed them to contain, as coating, uranium nitrate, gum, tannic acid, and a yellow colouring matter. On removing this coating by washing the plates with alcohol and water, the larger sensitiveness in green had disappeared.

Professor Vogel tried now to impregnate the silver bromide with a substance which would absorb chiefly the *yellow* rays, and would also bind the bromide set free through the action of the light. He selected corallin, an organic colouring matter, the alcoholic solution of which absorbs almost all light between E and D, and in a concentrated state, even below D, but which allows the blue rays about F to pass freely. An alcoholic solution of this body was admixed to the silver bromide, and plates were covered with this mixture. On exposing these plates to the spectrum, the experimenter's supposition was fully verified: *the plates were sensitive in indigo, which sensitiveness lessened towards light blue, becoming feeble at F, but beginning to increase here, and gradually rising in effect towards yellow.*

Here then was a means to make silver bromide plates of equal sensitiveness in yellow as in indigo.

Of course, the question presented itself now: Could the silver bromide not be so prepared as to feel equally well the power of the red rays? The answer was soon given by a green aniline colour, which in solution absorbs the red between D and C, and, in concentrated solution, beyond D.

Emboldened by these successful experiments, Professor Vogel ventures to predict, that at no distant time we shall be able to photograph in any colour—the very ultra-red, perhaps, just as we do the ultra-violet.

ON HEATING RAILWAY CARRIAGES IN GERMANY.[1]

THE Baden Railway.—Here the use of hot air has been tried. A little furnace, in which coal is burned, is placed under the carriage, as near as possible to one of the extremities. A chimney-tube crosses the whole length of the carriage, being at the other extremity brought up as high as the roof. Both furnace and tube are surrounded with a covering fitted with self-acting valves; these, when the train is in motion, admit the outer air, which is then carried into the interior of the compartments by means of conduits and valves fixed in the most convenient places. They also on the Baden railways make use of the hot-water feet-warmers on an extended scale.

The saloon carriages are generally provided with sheet-iron stoves in which charcoal is consumed; a great number of the third-class carriages are fitted with cast-iron stoves for burning coal.

In the carriages of express trains they have lately adopted a system of warming by means of the steam produced by an independent generator; and at present they prefer this mode of heating to that adopted on the Bavarian lines, of which we now give the description.

The Bavarian Railways.—Hot-water feet-warmers are generally used; but recently all the carriages of the express trains have been fitted with a steam-warming apparatus fed by an independent generator placed in a special waggon.

This waggon contains a vertical boiler, a little reservoir of water to supply it, room enough for coal and the stoker, and pipes to carry the steam to the front and the rear of the waggon. A longitudinal tube passes under each carriage. A vertical branch-tube corresponds to each row of seats, and leads the steam into a transverse pipe, which goes all through the compartment, and warms it. All the tubes, those under the carriage as well as those inside, are placed in such a fashion that the condensed water can easily pass away through taps which are constantly left a little open. The connection of the tubing of two adjoining carriages is effected by means of a caoutchouc tube in the form of a U, fitted with bronze couplings at the two extremities, and with a little tap in the middle.

These are the average prices of the apparatus:—

For a carriage with	4	rows of seats	300 francs.
"	6	"	525 "
"	8	"	660 "
"	10	"	800 "

The consumption of coal is only about one-half kilog. per kilometre.

So far this system has yielded satisfactory results. But they have recognized the necessity of attaching to each train a man specially charged with the conduct and care of the warming.

Railway from Berg to Mark.—Until quite recently they here used hot-water or hot-sand feet-warmers for the first and second class carriages. But they have just adopted a system of warming by the combustion of a brick of patent fuel (based on charcoal) in the inside of wrought-iron cases placed under the seats in boxes of thin cast-iron. The cases containing the fuel-bricks are introduced through each side of the carriage. They

[1] These items are condensed from a report lately made by order of the Austrian Government.

light the bricks upon coke fires, and bear them to the carriages in little iron tongs. With this system the temperature of the compartment is agreeable, and there have been no complaints of ill odours. In brief, the results are considered satisfactory.

Railway from Berlin to Anhalt.—On this line the utilization of the escaping steam has been tried. The directorate also intend to cause a waggon to be constructed containing a steam generator, a urinal, and boxes and compartments for the guards. This waggon will be placed in the middle of the train, and will transmit its steam both fore and aft. Hitherto hot-water feet-warmers have been used for the first and second classes. The directorate of the Anhalt Railway are at this moment commencing their first experiments as to heating by fuel-bricks. Under every row of seats there is a box or cover, which extends only as far as the centre of the carriage, and is raised about ·05 m. above the flooring. These covers or boxes are always put in at the left side of the compartment. The bricks are placed in perforated cases, all covered at the top, made of strong iron wire, being themselves enclosed in other cases of cast-iron, fitted with a handle at either end. The bricks are lighted by means of gas, by placing the iron-wire cases which contain them upon a grating formed of gas-tubing of about ·030 m. in diameter, pierced in the upper part with holes for the combustion of the gas. The gas apparatus is near the starting point, and the burning bricks have to be carried to the carriages.

Railway from Berlin to Hamburg.—Economical reasons have hitherto prevented the managers of this line from warming the third and fourth-class carriages. As to those of the first and second, the ordinary hot-water feet-warmers have been used. However, since 1868 a certain number of carriages have been heated by steam taken from the locomotive itself. The steam-tube, about ·045 m. in diameter, is fixed under every roof, with a slight inclination towards the extremities, which are always placed at right angles to the carriage, and this necessitates a double curve at one of the ends. The connection between the tubes of two contiguous carriages is effected by means of a caoutchouc tube fastened upon the two cocks. The tube is slightly elevated in the middle by means of a little cord, so as to prevent the water in the pipes from accumulating there. Little vertical conduits, ·015 m., bear the steam into tubes of ·105 m. diameter and 1·70 m. long, made of strong copper, and placed beneath each row of seats. Each vertical conduit is fitted with a top to regulate the admission of the steam, and the extent to which the top is opened is regulated by means of a handle placed outside the frame-plate. By this means they can stop the introduction of the steam, if it is necessary, into any one compartment. In practice they ought, according to the complaints of the travellers, to altogether renounce the admission of steam by means of the tap, and content themselves with maintaining an average temperature of 10°, which is found to be quite sufficient.

The transverse tubes have a slight inclination to one side of the carriage, and at the corresponding extremity a little vertical pipe carries the condensed water into a second longitudinal tube, ·025 m. in diameter, fitted at each end with a little tap, which, when the train is in motion, leaves a slight opening. The vertical conduit has a joint in its centre, and between the two flanges there is a sheet of metal pierced in the middle with a hole which is only ·004 m. in diameter, so as to allow the water to flow without permitting the steam to enter into the compartments which have been isolated from the principal tube. All the tubes are surrounded with a good covering. The carriages furnished with the apparatus we have just described have been in use since the winter of 1868-69, and the results obtained may be considered satisfactory; for even during the rigorous winter of 1870-71 not one single tube was ever frozen.

Railway of the Grand-Duchy of Brunswick.—One first-class and one second-class carriage have been supplied, as a trial experiment, with a water-heating apparatus on the Perkins system. Another passenger carriage has been furnished with a double floor, between which were placed cases containing hot sand, introduced from the inside. A third-class carriage received a stove lit from the outside. They regulated the uniform admission of the heated air by means of registers. They have made experiments on a large scale upon the value of warming by steam borrowed from the locomotive, and passing through the two copper tubes placed longitudinally in the interior of the boarding, the junction of the tubes between two contiguous carriages being effected by means of caoutchouc piping.

The Breslau-Schweidnitz, and Freiberg Railway.—Cases filled with hot sand were introduced below the seats of the compartments of the first and second classes, by openings cut in the sides of the carriages. During the winter of 1871 they placed a passenger-train, composed of six carriages, on the line, every compartment of which, from the first to the fourth class, was warmed by steam directly borrowed from the locomotive by means of an expanding valve, and carried by heating tubes placed under the bottom of the tender. The steam-tubes of the carriages were fitted at either end with a separating box, like the buffer-boxes, the straight end of which bore transversely a circular groove fitted with a caoutchouc ring, itself crossed by a metal connecting tube, so formed as to allow for the oscillating motion of the carriages. The boxes have mould-boards, on which, by means of brackets fitted with clicks, the articulated traction rods are gathered together on a lever pivoting round an axis fixed in the middle of the connecting tube, an arrangement which allows a very speedy coupling and uncoupling, and at the same time affords every possible security against the accidental formation of any stoppage. The heating tubes are placed beneath the seats of the third-class carriages. But in the fourth class they are placed between the seats (so as to make one serve for two rows) in wooden boxes, where the warm air can circulate freely, and which prevent the travellers from coming into contact with the pipes. All the condensed water is collected at two points in each carriage, and carried off by means of two taps. By opening these taps successively, and by beginning at the last carriage, so as not to interrupt the communication with the boiler, the pipes are completely emptied before they have time to cool. To render all congelation impossible, it is enough to leave the last tap constantly open. The whole of this plan has been copied from that in use on the railways of High Silesia.

The Railways of High Silesia.—Here they have made experiments with stoves enclosed in a covering. But this method was found dangerous, as the carbonic oxide accumulated in the carriages, and the stoves were liable to rust. In 1865 they tested on a large scale the use of steam borrowed from the locomotive. The steam passed underneath the planking through two copper tubes, with an elliptic section covered with wrought-iron plates pierced with holes, and surrounded with non-conducting substances, to prevent cooling as much as possible. The tubes communicated at each end of the carriages with a cast-iron box fitted with valves for the flow of the condensed water, as well as with taps, over which the caoutchouc tubes connecting the pipes of the two contiguous carriages met together. Since the year 1869 they have adopted the apparatus already described in our brief account of the Breslau-Schweidnitz Railway. The compartments of two first-class carriages are warmed by means of boxes fitted with hot sand, which are introduced from the outside.

The Railway on the right bank of the Oder.—The carriages of mixed trains are not warmed at all.

The Rhine Railways.—A saloon carriage is fitted with tubes filled with warm water by means of a little stove hung outside between the buffers. Another first-class carriage is warmed by hot air in an analogous manner. Hitherto feet-warmers have been in general use, but heating by means of bricks has just been introduced into forty-four carriages. The heating-boxes, instead of being placed under the seats, are placed between them, and this is possible because the body of the carriage is divided by a kind of frame ·075 m. thick. The arrangement is preferable because it avoids heating the seats, which might present sundry inconveniences. On this line fuel for heating bricks is costly, but the arrangements are very serviceable. They are now making experiments in heating the whole of a carriage with a single fuel-brick fire.

We give a few details upon the apparatus actually in use. A wooden box lined with sheet-iron is placed between the seats, its top side being level with the planking. In this box, but isolated from it, two thin copper or brass cases are fixed. A tube fitted with a double opening carries the cold air into these cases, into which they introduce morsels of fuel-brick, about three centimetres across, upon a grate with a handle. These morsels of mineral are chemically prepared, and burn from twelve to eighteen hours, according to their dimensions and the manner of preparation.

The bottom of the wooden box is covered with a sheet of iron ·006 m. thick, slightly curved and raised on each side for a height of ·06 centimetres, but fitted with a tap in the central part. To protect the feet of the travellers against too direct a contact, and to prevent the ashes from falling upon the cases, and giving out a foul smell, these cases are surrounded with a thin zinc covering pierced with holes on all its sides. On each side, too, this envelope forms a kind of gutter, from which the ashes can be easily cleansed by taking out the wooden box. The latest experiments justify the authorities in highly recommending this mode of heating, and orders have been given for its application to all the carriages on the line from Berg to Mark.

We have here given only some few of the principal facts, but the whole report has reference to fifty-five different German railways.

H. C.

GEMS OF INDUSTRIAL ART.--CABINET IN EBONY AND IVORY, RENAISSANCE STYLE.

By Hunsinger.

A TRADE UNION OF CAPITALISTS.

THE London correspondent of the "Manchester Guardian" writes to that journal:—"An important meeting has been held in London for the purpose of establishing a National Federation of Associated Employers of Labour. The fact that such an organization was contemplated has, I believe, already been announced, but it has now been accomplished, and, as its influence is very likely to be felt sooner or later in a very marked manner upon the disputes between capital and labour, I propose to set forth some of the objects for which this association has been formed. In general terms this society may be described as a combination of employers established to counteract the influence of Trade Unions. It is, in fact, an amalgamation of employers' associations, united for the common object of defending capital against the unjust demands of labour, whether they are made through the channel of legislation in Parliament, or whether they are made through the medium of strikes. The promoters profess that their organization shall be purely defensive, and hence they decline to 'emulate the Trade Unions in expenditure.' They propose to collect and disseminate throughout the country information bearing upon industrial questions, for which purpose it is in contemplation to establish a weekly or a fortnightly newspaper. The federation will also watch over every legislative proposal affecting employers and employed, with a view to influencing the same; it will encourage the independence of non-unionists, and endeavour 'to give to education, intelligence, and capital their fair share of influence in the constituencies.' It would, therefore, seem from the rules and printed documents of the federation that the employers have determined to accept the gauntlet of the working men unionists, and to fight them—if that unhappy necessity should ever arise—with their own weapons. The success of such an ambitious object as this very greatly depends upon the influence and position of the men who take it in hand, or who give it their approval. It would, I think, have been almost impossible to have secured better names with that object than appear upon the list of the council. The majority, no doubt, belong to Lancashire and Yorkshire; but it may not be forgotten that it is in those two counties that we find the largest employers in the kingdom. The president of the association is Mr. J. Robinson, of the firm of Messrs. Sharp, Stewart, and Co., Manchester. The other members of the council are—Sir James Ramsden, Barrow; Mr. B. Hannen, of the firm of Holland and Hannen, London; Mr. J. Crossley, of Halifax; Mr. Richard Hayworth, of Manchester; Mr. J. Brinton, of Kidderminster; Mr. J. Laird, of Birkenhead; Mr. S. A. Marshall, of Leeds; Mr. W. Malcolmson, of Portlaw, Ireland; Mr. W. B. Briggs, of Birmingham; Sir John Savage, of Belfast; Mr. Edmund Ashworth, of Bolton; Mr. James Wilson, of Leeds; Mr. E. Gilkes, of Middlesbrough; Mr. Titus Salt, of Saltaire; Mr. Robert Neill, of Manchester; Mr. T. R. Bridson, of Bolton; Mr. W. Morris, of Halifax; Mr. R. Raynsford Jackson, of Blackburn; Mr. Anthony Bower, of Liverpool; Mr. J. Menelaus, of Dowlais; Mr. E. Akroyd, M.P.; Mr. F. M'Cance, of Belfast; Mr. Field, of the firm of Maudsley, Son, and Field, London; Mr. Vickers, of Sheffield; Mr. Joseph Simpson, of Manchester; Mr. Robert Tennant, of Leeds; Mr. Trollope, of Westminster; Mr. E. J. Harland, of Belfast; Mr. W. J. Ridout, of London; Mr. W. Knowles, of Bolton; Mr. Stanley G. Bird, of London; Mr. O. Graham, of Belfast; Mr. Bennett, of the London Tailors' Association; Mr. C. N. Peel, of the West-end Shoemakers' Association; Mr. J. Oldroyd, of Dewsbury; Mr. E. Johnstone, of Manchester; Mr. E. J. Smith, the Earl of Dudley's agent in North Worcestershire; Mr. Peacock, of the firm of Messrs. Beyer and Peacock, of Manchester; Mr. R. Thompson, of Padiham; Mr. James Coombe, of Belfast; and Mr. Davies, of the firm of Davies and Eckersley, Manchester. Among the associations which have become affiliated to the federation are the Master Cottonspinners and Manufacturers' Associations of Preston, of Blackburn, and Burnley; the United Bleachers' Association of Lancashire and Cheshire, the Engineers' Association of Belfast, the West-end Master Bootmakers' Association, the Master Worsted Spinners' Association of Halifax, the Master Cottonspinners' Association of Manchester and Salford, and of Bolton; the Master Builders' Association of London, of Birmingham, of Manchester, and of West Yorkshire; the Iron Trades Employers' Associations of Barrow-in-Furness, Barnsley, Bradford, Bristol, Halifax, Huddersfield, Keighley, Leeds, Leicester, Lincoln, Liverpool, Birkenhead, London, Manchester, Nottingham, and Wakefield. The names above given will indicate in some degree the success which has attended the earlier stages of this movement, and the enormous influence that surrounds its *début*. The workmen employed by the masters belonging to the associations above enumerated are estimatcd to number nearly 2,000,000."

THE PREVENTION OF RAILWAY ACCIDENTS.

A REPORT has been issued by a committee of the Chamber of Commerce of Edinburgh on railway accidents, which is to be submitted for approval to a special meeting of the chamber. The committee, after referring to the frequency of railway accidents during the last few months, remark that great as public alarm is, it would be still greater if the number of narrow escapes frequently occurring were made known. They point out the very misleading character of the parliamentary returns on railway accidents. Of the erroneous information conveyed by these returns they say:—

"As is well known, two of the heads of that classification are 'killed' and 'injured.' The number returned as killed in 1872 within the United Kingdom is 1,145. From investigations which your committee have made they have every reason to believe that the former are greatly understated. In many instances the person returned as 'injured,' because not killed on the spot, has actually died before the return is made; and still more frequently a fatal issue occurs shortly afterwards. In order to put this beyond the possibility of dispute, your committee made application to the principal infirmaries in Scotland for returns of patients admitted owing to injuries caused by railway accidents during the year 1872, with their names, dates of admission, and results in each case. From the answers which have been received your committee find 35 cases which ended fatally; but, on comparing these with the Blue Book ('Railway Accidents, 1872,' c. 843, in pursuance of 'Railways Regulation Act, 1871'), in which every individual case returned by the railway companies is specified, they find only 13 of these 35 fatal cases entered as 'killed.' Of the others 12 are recorded, but only as 'injured;' and 10 of them are not entered in the parliamentary returns at all so far as your committee can trace, thus confirming, even in cases ending fatally, the doubt expressed by the Board of Trade as to the completeness of the railway companies' returns. It thus appears that only 37 per cent. of deaths occurring in infirmaries in Scotland, the result of railway accidents, are to be found among the 'killed' in the railway returns, as printed and circulated by the authority of Parliament. The number reported in the parliamentary returns for the same year as 'killed' in England and Ireland is 977. Supposing the same proportion held good as in Scotland between the number so reported and the deaths in infirmaries or hospitals which proved to be not recorded as killed, *i. e.* the proportion of 168 to 22—and there is no reason to suppose it would be any less—it would follow that an addition of 128 would have to be made, giving 150 deaths in infirmaries in the United Kingdom in 1872, the results of railway accidents not recorded in the parliamentary returns for that year. Again, it is well known that in many cases the sufferers from railway accidents are carried to hotels or private residences. There can be little doubt that a large proportion of those terminating fatally in such circumstances is unrecorded in the returns. Supposing there were only half as many as in the infirmaries, there would be a further addition of 75, bringing up the total from 1,145 to 1,370—a number which, your committee fear, would still be short of the truth. It may serve to produce a more adequate idea of this fearful loss of life, if it be compared with that which occurs on the field of battle. It so happens that the number last brought out almost exactly corresponds with that of the 'killed in action' of the British Army in one year of the Crimean War. The entire number was 2,755, which, if equally distributed between the two years during which the war lasted, would be 1,377 each year, against 1,370 deaths from railway accidents in the United Kingdom in 1872. Keeping in view the frightful casualties of the present year, there can be no question that more deaths have resulted from railway accidents in the United Kingdom in the last two years than were killed in action of British soldiers during the two years of the Crimean War."

The committee believe that the causes of the frequent accidents are already sufficiently ascertained, and they think it a mistake to suppose that any amount of investigation will bring to light causes not presently known and recognized as occasioning these disasters. They consider it their main duty to suggest a mode of enforcing the well-known means of preventing accidents, and the better to do so they briefly enumerate their

prominent causes. They arrange them into two heads—first, those connected with the plant, and, second, those connected with the administration. Among the former they specify the following causes :—(1) "Facing-points"—the cause of the late frightful catastrophe at Wigan ; (2) the want of adaptation of the carriage steps and the station platforms, causing a space between them, into which passengers or servants frequently fall, very often with a fatal result ; no fewer than 66 lives were reported as lost last year from this cause alone ; (3) the non-adoption of the system of interlocking points and signals ; (4) insufficient facilities for goods traffic both at terminal and roadside stations, especially the want of sidings of adequate number and length—a frequent cause of collision. The causes of accidents connected with the administration they believe to be of more importance even than those connected with the plant, and among them they enumerate—(1) Want of discipline on the part of the *employés ;* (2) excessive hours of labour ; (3) facilities for railway servants obtaining intoxicating liquors ; (4) irregularity of trains ; and (5) excessive speed, especially in particular circumstances.

Of excessive speed, they say :—

"Contrary to the popular opinion, this does not appear as a frequent direct cause of accidents ; and when it does, it is usually not in trains which perform a long journey at a constant high speed, and with few stoppages, but in such cases as that last supposed, in attempting to make up for time lost at stations or otherwise. But in the opinion of your committee there can be no doubt that excessive speed operates largely as an indirect cause of accident, many of those casualties which are directly attributed to the fracture of machinery, looseness of rails, &c., being probably due to the excessive speed to which all directorates ascribe the great tear and wear of plant. It must also be borne in mind that when an accident does occur, the calamitous consequences are greatly intensified if the trains be going at an excessive speed."

The remedial measures suggested by the committee refer first to the plant. They suggest the adoption of one uniform code of signals for all the railways in the kingdom. By that means, they observe, a servant might pass from the employment of one company to another without danger to the public from his requiring to unlearn his former code and to make himself familiar with a new and different one. They recommend that authority be lodged in a department of Government for enforcing the adoption of such undoubted improvements as have been sufficiently tested by experience : as also for compelling the enlargement of accommodation for traffic, such as additional rails, sidings, &c., adequate for performing the operation of shunting with safety, the want of which has been pointed out as a frequent cause of accidents.

Coming to the causes of accidents connected with the administration, the committee recommend the prohibition of mixed trains on the main lines. They think the limitation of the size of trains is a subject for consideration, and they remark that there are few accidents reported in connection with the limited mail trains, which, as their name imports, are restricted under heavy penalties to a certain number of carriages. They think it may be for consideration whether the companies should not be held responsible under suitable penalties for the punctual arrival of all trains. The effect of such a measure would probably be that they would publish only such hours of arrival as they could certainly expect to keep, and that they would enforce such punctuality on their servants that not only would the public be saved the great inconvenience arising from the present irregularities, but a fruitful cause of accident would be removed. The committee suggest whether it might not be for consideration by the Legislature to fix some limit to the rate of speed, not merely over an entire journey, but in any part of a journey, and especially to lay down a strict limit for the rate of speed in passing facing-points. The committee are strongly inclined to recommend the total prohibition of the sale of intoxicating liquors at all but the principal railway refreshment-rooms. They would make it a penal offence on the part both of refreshment-room keepers and passengers either to sell or to give intoxicating drinks to railway officials, and, of course, on their part to buy or accept of them. They strongly recommend the universal and imperative adoption of the block-telegraph system. They no less strongly recommend the limitation by statute of the hours of labour of guards, drivers, signalmen, &c., on whose efficiency the safety of the train depends. They are of opinion that, except in special cases, to be sanctioned by the Board of Trade or by a new Railway Commission, no such servant should be required or permitted to be on duty, without sufficient cause being shown in the proper quarter, for more than ten hours per day, under severe penalties for infringement of this enactment.

With reference to the enforcing of discipline the committee say:—

"The Railway Regulation Act (1871), already referred to, exacted the returns from railway companies which have been quoted in this report, and conferred on the Board of Trade specific powers of inspection in cases of accident, but no power of enforcing regulations, or of punishing breaches of them. The extracts quoted by your committee are sufficient proof of this assertion. Evidently, what is wanted is some provision for that purpose. Fortunately, the machinery already exists ; all that is required is the conferring of powers on it which it does not at present possess ; in other words, the enacting that the duty of enforcing the acts and regulations already referred to shall be part, and that a principal part, of its work. As just stated, the Board of Trade already exercises a certain power of inspection—it can scarcely be called authority—in railway accidents. In the last session of Parliament there was a new tribunal created, called the Railway Commissioners, mainly for the purpose of deciding questions which might arise between railway companies, or between the companies and the public in the matter of traffic facilities. An opinion was expressed in this chamber at the time the measure was passing through Parliament, that greater powers should have been conferred upon the commissioners than the statute gave them."

They suggest :—

"1. That one or other of these bodies should have the power, within certain limits, of ordering the adoption of such improvements and precautions, both under the head of plant and of administration, as your committee have indicated, and of others as from time to time may be requisite. 2. That a fully organized staff of inspectors be appointed for the purpose of enforcing all enactments, whether by the Legislature, the Board of Trade, the Railway Commissioners, or the companies themselves, in the interest of the public, and for the detection of breaches of the same, whether by the companies or by their servants. 3. That, on the report of these inspectors of the infraction of such enactments, the Railway Commissioners shall either try the charge themselves, or direct that it be tried before any competent local tribunal, with power to inflict such punishment or penalties as may be sufficiently deterrent both to individuals and companies."

HEAVY GUNS.[1]

WHEN Mr. Goschen announced in the House of Commons a few months ago that preparations were being made for the construction of a new vessel of war which should possess far greater powers both of attack and defence than any ship hitherto designed, it was foreseen by artillerists that the contest between guns and plates, which had, of late years, lost much of its intensity, would again rage with fresh vigour. Unfortunately, as the guns and plates grow, so does the expense ; but a considerable amount of knowledge and experience has already been gained, and though it cannot be said that the true law of penetration and resistance has been as yet accurately determined, yet certain approximate calculations have been formed, partly from the known principles of dynamics and partly of an empirical character, by the aid of which a great deal of information may probably be acquired from a few trials ; and thus, though each experiment may be costly, frequent repetition will be unnecessary.

It is certain that, though England is at this moment in advance of any other Power in the number and force of her heavy guns, yet a brief pause in her progress would suffice to throw her behind in the race, and to permit other nations to use her acquired experience as a stepping-stone, whence they could lightly pass on to greater achievements. England is at present in the van with three turret-ships armed with 35-ton guns, and these weapons will be improved upon by the new 38-ton guns now being constructed ; but the great German gunmaker is prepared to produce 60-ton guns, having a calibre of 15 inches ; and, indeed, he exhibited a block of steel ready for boring to this size at the Vienna Exhibition. It is understood that a well-known English house has been in communication with more than one foreign Government on the production of guns weighing 60 tons, and that certain preparations have already been made for their manufacture.

It may, therefore, be taken for granted that the weapons alluded to by Mr. Goschen will weigh at least 60 tons—it is probable that they will be even larger ; for Lord Lansdowne has stated in Parliament that no difficulty would be experienced

[1] From "The Times" of December 11.

by the Royal Arsenal in making guns of even 100 tons, and we shall not err greatly in assuming the weight of the new guns at 80 tons. Be the ultimate decision what it may in respect to size, the same principles of construction will equally apply, and it will doubtless interest many to know what these principles are.

The object to be obtained is, of course, to hit a mark and do as much damage as possible; we have, therefore, in designing very heavy guns to seek for accuracy and penetration as our two special qualities. Accuracy depends to a very great extent on the rotation given to the shot; as far as has been ascertained at present, the quicker the spin the better the shooting. Rotation must not, however, be confounded with angular velocity, in the artillery sense of the word at least, since it means the rate of travel of a point on the surface of the projectile round the axis in feet per second, while angular velocity, of course, refers to the number of turns in a second. Thus the 7-pounder now throwing shells among the Ashantees projects them with a speed of about 750 f.s., which will cause them to turn 150 times in a second; their circumference is about 9 in., and thus a point on the surface rotates at the rate of 112 ft. per second. The 35-ton gun, on the other hand, generates a velocity of 1,300 f.s., and its projectile turns 37 times in a second, while a point on the surface rotates also about 112 ft. per second. Now, the shot which has been adopted into the service as giving the best results against iron plates or other defences is about two and a-half times longer than its breadth; and for a projectile of these proportions experience has shown that a rotation of not less than 80 or 90 ft. per second is required to give steadiness, and, therefore, accuracy. Since the friction of the atmosphere tends to reduce the rate of rotation, it is necessary to start the shot with some excess of spin, and it has been found that the rate of 112 f.s. gives satisfactory results. In rifling a newly-designed gun, we have, therefore, to estimate the muzzle velocity likely to be obtained by the intended charge, and from this estimate we can at once fix the angle of rifling. It would be injudicious to make it unnecessarily large, because the work done on the gun and projectile—that is, the wear and tear—would be increased thereby. Thus the velocity of the shot regulates the angle of rifling, and it also regulates the penetration into iron plates, which varies, when other things are equal, with the weight of the projectile multiplied by the square of its velocity. It becomes, therefore, a matter of great importance to obtain the highest velocity compatible with the safety of the gun and the cohesion of the shot. The action of the charge is twofold on the gun, and twofold on the shot. It tends to burst open the walls of the former, and also to blow its breech off. It tends to drive in the base of the latter, and also to wrench its sides open in giving rotation. Taking the case of the gun first, it is evident that if the powder were instantaneously converted into gas, the pressure in the chamber before the shot began to move would be very great; but if the ignition be slow, comparatively speaking, the shot will have been driven forward a certain distance before the powder is completely burnt up, and there will, therefore, be a larger space behind the shot to contain the gas evolved. This is the principle which has led to the introduction of pebble powder, which is slowly consumed, and, while giving a diminished *maximum* pressure, continues to throw off fresh supplies of gas as the shot proceeds through the bore. If the gun were cut short, the early impulse would alone be effective, and thus it is that the slower the rate of burning of the powder the longer must be the gun, if the necessary velocity is to be obtained, and conversely, if circumstances will permit the employment of a long gun, a slow powder giving a mild *maximum* pressure can be employed.

As regards the force acting on the base of the projectile, the same reasoning applies, and we have now only to consider the power acting on the sides of the shot to give rotation. There are two methods of rifling employed in our service, the uniform and the increasing spirals, and, indeed, all foreign systems belong to one or other denomination. The uniform spiral is formed by winding a straight groove round the bore, like the thread of an ordinary female screw; the increasing spiral is formed by winding a curve, such as a parabola, round the bore in such a manner that at the end next the breech the angle of the rifling is 0 deg., but increases gradually to the required amount at the muzzle. Supposing a shot half way through the gun to have acquired a certain velocity of translation and rotation, it will continue to move forward and rotate at the same rate if not acted on by any additional force—*i.e.* if the explosive power be exhausted at this point; if, therefore, the gun be rifled with the uniform spiral, the shot will no longer be dependent on that spiral for its rotation, having already acquired the utmost spin the rifling can give. If, under the same circumstances, the spiral were an increasing one, it is evident that it would give additional rotation to the shot during its whole passage through the gun.

But the explosive power is not exhausted till the projectile arrives at the muzzle, and therefore pressure is still exerted on the base of the shot, giving an increase of velocity at any point which is dependent on the pressure at that point. In the case of the uniform spiral the increase of rotation proceeds *pari passu* with the increase of velocity; in the case of the increasing spiral the increase of rotation is compounded of the increase of velocity and the increase of the angle of the rifling. Now, to give a certain amount of rotation to a projectile of constant weight a certain amount of work must be done, whatever spiral be used; if more work be done, more rotation will be imparted; if less, less.

Whether the gun be rifled with the uniform or with the increasing spiral, the shot leaves the muzzle with exactly the same spin, as the final angle of the increasing spiral is the same as the constant angle of the uniform spiral, and thus we find that the principal difference in the action of the two systems is that nearly all the rotation is imparted to the shot soon after its first start, in a gun rifled with an uniform spiral, while the nature of the increasing spiral spreads the work over the whole length of bore. It is true that the work rises towards the muzzle, but it never attains the *maximum* given by the uniform spiral at the breech-end of the bore. The exact advantage in this respect obtained by the increasing spiral formed by a parabolic curve, over the uniform spiral, varies in different guns according to length, charge, &c., but may be taken, in guns of the latest design, to be about 13 to 8, assuming that well-adapted slow powders are employed; with a rapidly-burning powder the advantage would rise to about 19 to 7. This, with very heavy guns and proportionately weighty projectiles, is obviously a most important consideration, since on it depends the liability of the shell to be wrenched open at the sides by the mechanism adopted for imparting rotation.

With regard to penetration into armour plates, it appears not improbable that steel may be employed for the material of the projectile, as many difficulties present themselves in manufacturing shot of the vast size that will now be required, probably weighing two-thirds of a ton each, from the chilled cast-iron which has answered so well with the smaller guns in use up to the present time. Whichever material may be adopted, there is no doubt that the power of the new gun will very far exceed that of any weapon hitherto designed; and England may be congratulated on the prospect of leaving all competitors so far behind that a long time must elapse before she need fear renewed rivalry.

THE IRISH POPLIN TRADE.

By C. Drew.

ABOUT the month of October, 1685, a private marriage was celebrated at Versailles, so secretly that the date of its celebration has been ever since a matter of controversy. Yet its influence was to pervade all the history of that century and all which have followed it, to affect the lives, liberties, and fortunes of hundreds of thousands of people, and to colour the religion, the politics, and the commerce of our own time.

When the Jesuit confessors of Louis XIV. consented to and performed the marriage between him and Madame de Maintenon, the widow of the witty cripple Scarron, who had married her when little more than a child from the Ursuline convent at Paris, the condition imposed was, that madame should use her influence over Louis to obtain the revocation of the edict of Nantes, by which Henry IV. had granted equal civil and religious liberties to all his subjects, Protestants and Roman Catholics alike.

How she fulfilled her pledge, and the results which followed, are matters of history; for us the scene shifts to England, where the refugees found a home, and further still, to Ireland, which through French industry became the cradle and home of the poplin manufacture.

Out of the half-million of French subjects who were driven into exile by the revocation of the edict of Nantes, more than 120,000 are believed to have taken refuge in England. They were of all ranks and conditions, landed gentry, ministers of religion, soldiers and sailors, professional men, merchants, students, mechanics, artizans, and labourers. But for intellectual labour there was not sufficient demand in England to support all of the educated class who came over, and those who had been of the wealthy class in France were glad to be able to fall to the level of the artizans when they found themselves in

England; thus the number of the working-class immigrants was largely increased. Previous to this time all the velvets and satins worn in England were imported from France, chiefly from Lyons; silks and taffetas from Tours; silk ribbons, galloons, laces, gloves, and buttons, from Paris and Rouen; serges from Chalons, Rheims, Amiens, and various towns in Picardy; besides paper, ironmongery and cutlery, linen cloth, feathers, fans, girdles, pins, needles, combs, soap, aqua vitæ, vinegar, and many other articles for household consumption; and all at once, within six months' time, England found herself with large manufactories of all these things growing up and being carried on vigorously in her midst.

But the most important of all these branches of industry to which the refugees devoted themselves was the silk manufacture in all its branches—satins, brocades, velvets, paduasoys (figured and plain), and, above all, black lutestrings, which, being especially made for the English market, were known as "English taffeties."

The workmen of Tours and Lyons set up their looms in Spitalfields and Bethnal Green, and a common workman from Lyons brought over the secret, then but recently discovered, of giving lustre to silk taffety.

Thus the manufacture of silk in England had far advanced towards perfection when the English revolution of 1688 gave a new turn to events. With William of Orange came over to Ireland not alone Englishmen, but a crowd of the French refugees who had found an asylum in the Low Countries, with many also of those who had come to England and not yet found employment there. After the war was over, and William III. settled on the throne, he revived an old bill which the Irish parliament had passed in 1674, suspended afterwards by the parliament of James, granting naturalization to such Protestant refugees as should settle in Ireland, and guaranteeing them the free use of their religion.

In the centre of the city of Dublin, south of the river Liffey, lies a rather unsavoury district, densely populated, and consisting of old streets, with dingy houses, once stately mansions, but now let out in tenements, with ill-paved, much worn streets, known as the Earl of Meath's Liberties. This at one time was known as the city proper, special privileges having been granted to it by successive English sovereigns, and a charter by Henry VI., which was confirmed and enlarged by his successor, Edward IV.

Here the French refugees set up their looms and began to work. As early as in the fifteenth century a fabric had been woven in Avignon called *papeline*, which was made of silk, and was much esteemed. What was its exact nature is not known, but that some traditionary material which was the first poplin known was still made in the south of France in the seventeenth century, when the silk weavers fled to England, there can be no possible doubt. Dr. Cooke Taylor is our authority for ascribing the first organized manufactory to an ancestor of the La Touche family, who have since been known in Ireland as bankers. They called the work which was done in their looms, tabinets, or poplins, or tabbareas, and their works commenced in 1693, two years after William III. concluded the peace of Limerick. Indeed, the banking house itself, in Castle Street, Dublin, had its origin in the poplin trade, for the high character for integrity which the Mr. La Touche of that day maintained caused him to be made the general depository of the funds of the little community. The Weavers' Hall, of which mention is made further on, was erected in the Combe at the sole expense of Mr. Digges La Touche, Warden of the Guild. The success of the first silk weavers in Dublin induced others to leave England and come over and join them. Street after street sprang up, and from being one of the poorest quarters of the city, the Liberties became the richest and most prosperous. The names by which the now decayed streets are still known, show that they were originally bestowed by English settlers. The Combe, Pimlico, Spitalfields, and other names were called after corresponding streets in London. Writers of a luxuriantly imaginative turn of mind have set forth that the Combe must have had its name from the combing of the wool, which was done there when wool was the staple trade of Ireland; but the derivation is simpler still. It is a valley enclosed, except on one side, by mountains, a nook, or glen; in Devonshire and Somersetshire the term is a familiar one, and the track of the river which wound through the Dublin Combe is still well defined by the inequalities of the ground, even had there not been old maps to prove its existence. Old houses once tenanted by the Irish nobility stand in the Liberties; the ceilings, woodwork, and chimney-pieces testifying to the artistic taste and skill of the workers as well as the wealth of the owners. During the last seven or eight years, since the passion for classicism sprang up and art work of the *renaissance* period became the fashion, speculative dealers have ransacked the old houses in the Liberties, and carried away all the remains of the work done by the French refugees and their descendants during the hundred years in which the silk manufacture enriched the city of Dublin. Many modern mansions in London have been decorated with these spoils, the owners all unconscious of their Hibernian origin. In the Foreign Office may be seen one of these old mantelpieces, bought for a song, cleaned, and sold to her Majesty's Government at a profit large enough to realize the wildest dream of a mercantile speculator.

A great and fatal error was made by the new settlers in the very outset of their career; they adopted the principle of excluding the native Irish from the benefit of all the improved arts which they introduced, refusing to receive them as apprentices. The manufacture was therefore an exotic, forcibly prevented from taking root in the soil, and deriving its support from artificial patronage. So weak, indeed, was it, that in 1733 the Irish manufacturers of silks and stuffs waited on Archbishop Boulter, who then virtually ruled Ireland, to obtain his influence in passing a law to prohibit the wearing of East India goods.

In 1749 an appeal was made to the king, through the Lords Justices, to remedy some of the abuses which had crept into the management of city affairs. A copy of the great charter granted by one king and confirmed by succeeding ones, translated into English, was set forward, with a preamble, very diffuse, very wordy, and very roundabout, a style which also characterized many of the state documents of that time. Doubtless the framer of the appeal, a Dublin freeman, believed it would be very convincing. The gist of the matter may be found after wading through twenty-six pages of the damp-stained old copy, bound in calf, which is in the library of the British Museum, thus:—

"Foreigners and aliens are upon a better footing than those who, by birth, by services, or at the expense of their treasure, have obtained their freedom."

So Irish grievances are not a plant of recent growth.

There is no record of any result from this ventilation of internal dissatisfaction; possibly the details never reached the royal ears. In the meantime the chief promoters used their influence with great success for what, in a spirit not very far-seeing, they believed to be for their own advantage.

Previous to the establishment of the silk manufacture in Ireland, the woollen trade had been the staple produce of the country. Irish blankets, Irish flannels, and friezes, were growing into repute in the English markets. The Yorkshire woolcombers took alarm. That Ireland, which they looked upon as a mere dependency of the British crown, should presume to interfere with English trade was not to be borne. An act of parliament was passed actually prohibiting the exportation of woollen goods from Ireland, and hampering the local trade with conditions which were perfectly ruinous to the manufacturer.

As a kind of compensation for this injustice, the silk trade was taken up, fostered, subsidized, and almost killed with kindness. The Royal Dublin Society had been for many years instrumental in promoting art and manufacture in Ireland. Theirs was the first annual exhibition of paintings, which gave London the idea from which has sprung the Royal Academy. Engraving was brought to a state of perfection which enabled the workers successfully to compete with those of any foreign country. Seal engraving in particular was a speciality. The drama and music flourished, and when no one in England appreciated the "Messiah," Handel took it over to Ireland, and had it performed for the benefit of the Lying-in Hospital in Rutland Square. As a specimen of what ordinary workmen there could achieve a little more than a hundred years ago, it is sufficient to examine the ceiling of the chapel to that same hospital, as well as that in the chapel to the hospital at Kilmainham, close by the south entrance to the Phœnix Park.

Under the protection of the Royal Dublin Society the poplin manufacture was placed, under whose auspices a central warehouse was established in Parliament Street, and a premium of £10 was offered to all manufacturers who should deposit there for sale silk goods made in Ireland.

This led, as might have been expected, to all kinds of fraud, the same goods being deposited over and over again in the warehouse, and a premium demanded on each occasion.

At no time, says Mr. C. G. Otway in an official report presented to the Imperial Parliament in 1840, did the value of goods in that warehouse exceed £12,000, and the average annual receipts scarcely reached £8,000.

So much for artificial encouragement of the trade of a country. One of our modern poplin manufacturers would smile at the idea of carrying on a business, the receipts of which to one manufacturer alone would not exceed by many times over those which official returns assure us came from the whole trade of Ireland. With the poplin trade it was as has been the history of many other branches of industry—monopoly gave indifference with regard to improvement; and that zeal

which fosters ingenuity, and which in manufactures always promotes unceasing efforts to produce the article in the best form, must be comparatively extinguished.

The six manufacturers who had the management of this hall in Parliament Street must have had singular ideas of arithmetic, for in the returns made to Parliament for the purpose of claiming the bounty, extraordinary discrepancies occur. In the year 1775 we are informed that 3,400 looms were at work, while the returns of the silk imported into Ireland for the weavers during the three years previously could not possibly keep more than 1,000 looms at work. Worse still, they report the amount of finished fabric as yearly increasing, while the raw material imported, as well as the number of weavers employed, was sensibly diminishing. For instance, in the period between 1765 to 1777, when the bounty system was in its full operation, the returns show 3,000 lbs. less of raw material imported, yet an increase of upwards of 3,000 lbs. in the finished fabric over what they returned as the results of the trade during the ten years before the bounty was granted.

In 1786, Parliament withdrew its support from the society's silk warehouse; then in 1798 came the Irish rebellion, which paralyzed every branch of trade, and even after tranquillity was restored, combinations and trades-unions were bars to progress. Large numbers of workmen left Ireland and went over to England, where at Macclesfield and other places their descendants may still be found. Notwithstanding that the Government in 1800 had laid a protecting duty of 10 per cent. on the introduction of foreign and British silks, trade languished. The heavy import duties which had not for the protection of any particular interest, but for revenue, been laid on raw silk, hindered the extension of the trade. On foreign organzine silk the duty was 14*s.* 7¼*d.* per lb., on raw silk from Bengal 4*s.*, and from other places 3*s.* 7¼*d.* In 1824, Mr. Huskisson proposed to reduce the foreign thrown to 7*s.* 6*d.* per lb., and in 1826 to 5*s.* Yet this did not sufficiently relieve the manufacturers, and the market was well supplied with smuggled silks, a trade which well repaid the risk run by the contraband trader. Even up to the year 1843, the Custom-house returns show that out of 484,438 lbs. of silk goods shipped from France for England, only 276,256 paid duty.

In 1826, with the reduction of the duty on raw silk, the protective duty was also withdrawn, and the workmen, not able to comprehend the altered spirit of the times, refused to meet them by modifying their laws; and the tabinet trade only existed, and little more, for many years, with occasional alternations of good and evil fortune. Sometimes when the caprices of fashion diverted the patronage into other channels, the silk weavers were plunged into destitution; then public attention being called to their condition, the wearing of home-made silk was advocated as at once benevolent and patriotic, and the example was set by the recognized queens of society. The factitious demand which was thus created only served for a little time to raise the poor weavers to a state of comparative comfort, but when the exciting cause was forgotten, and the influence which produced the demand died out, they lapsed again into indigence, and their last state was almost worse than their first.

All this description of the state of the trade is happily now past history; the present is not alone hopeful, but absolutely brilliant. Step by step Irish poplin has fought its way, not by Government subsidies, nor by protective duties, nor by any other adventitious aids, into a foremost place among the best manufactures of the United Kingdom. And these steps have been of such a nature that retrogression would be almost an impossibility. The heads of the chief firms in Dublin, who knew the trade in its fluctuations, and also of what it was capable, were men of intelligence, and, with scarcely an exception, men of scientific attainments. For years each man in his own manufactory devoted himself to perfecting the production of poplin, and their labours have been crowned with well-deserved success. That Irish poplin should be good and beautiful was their aim. That the work should be perfect in texture, in colour, in durability, and yet not alone in accordance with the most fastidious demands of fashion, but almost such as to anticipate it, has been the work of more than one man's lifetime. In every court of Europe dresses of Irish poplin are a necessity; and no princess, either in England or at any foreign court, has her *trousseau* completed without a large, so very large an order, that our veracity might be impeached were we to reduce to figures the quantity of poplin ordered from the Irish factories.

Though poplin is included in the returns of the silk trade, it is not all silk, but an ingenious combination of silk and wool, the weft being the finest wool, and the warp an equally fine description of silk, so woven that each surface, both upper and under, is entirely silk, while the interior of the texture is of wool. By this arrangement the article has all the lustre of silk, with much greater softness and fulness of texture. It is when poplin is allowed to fall in folds or drapery that its beauty is most to be seen. The flowing lines on which artists set such high value, and which are one of the distinctive features of the pictures of the old masters when they painted fabrics, give the best idea of what poplin can do. Even at a later period Sir Peter Lely or Sir Joshua Reynolds would have been distracted at the thought of drawing one of his beauties in the cotton-mixed, jute-pervading fabrics which go to make up the angular outline which the nineteenth century tolerates as the female figure.

Norwich, as well as Ireland, sells poplin, and at a much cheaper rate; but a moment's comparison of the fabrics from the two countries will explain the reason. In the English poplin the woollen thread is so thinly covered with silk, that the lustre which pure silk generously used can give is lacking. The English make is therefore duller, and will not wear nearly so long as Irish. What is called French poplin is familiar to ladies, and if they will only examine for themselves, they will find that the inner thread—the weft—is, if not entirely cotton, considerably mixed with it, and the warp, the scantiest possible coating of silk. The first exposure to a damp atmosphere is therefore destructive to these imitation poplins, while the Irish make has nothing to fear. The woollen thread, which is of the fine kind known as Jenappe, and selected with the greatest care, having been previously dyed, can shrink to no less dimensions; and so long as an Irish poplin dress is worn, what feminine phraseology styles "cockling" is an impossibility.

To reduce this difference between the poplins of the two countries to figures, the number of threads in the narrow dress breadth varies from 5,000 to 6,500, but is never less than the former number. That from the English looms has only 3,500 threads of silk in the same breadth, so that if the cost be reduced to the purchaser, it is at the expense of the quality of the fabric.

Another difference is in the use of warps and wefts not only of diverse shades, but of totally different colours, which may impose on the inexperienced buyer, but to the artistic eye has a muddiness of hue that destroys the delicacies of the lights and shades which make draperies in Irish poplin unlike those of many other materials.

Who invented this combination of silk and wool is unknown. It has been suggested that some manufacturer who, being short of silk, attempted to supply the deficiency with worsted, surprised himself as well as others by the new texture which resulted. A better idea is, that when the wool trade, which had been brought to such perfection in Ireland, was so suddenly suppressed by English legislation, it was tried to utilize quantities of fine wool which the merchants had in stock by working it into the fabric of which Government seemed inclined to make a petted, and as it seemed at one time, a spoiled child.

Poplins are divided into three classes, technically known as *single*, *double*, and *terry*. The first two are similar in appearance, the double only differing from the single in the quantity of silk in the warp.

The third is like richly corded silk or terry velvet, but being the same on both sides, is an economical as well as a handsome dress for a lady to purchase.

Both the single as well as the double poplin are made figured, a pattern in brocade being thrown up. For some years there was little demand for this style, but the whirligig of fashion has come round once more, and brocaded or figured poplins bid fair to be *de rigueur* during the coming season.

Tartans are also made in poplin, and, as the silk is dyed before it is woven, the colour is durable, and the pattern the same on both sides.

For a long time poplin weaving was but little carried on in large factories, but, like linen and muslin, was made in the weaver's own house. At the master's factory was stored the material to be issued to the weavers, and there they brought the web when finished, and received payment according to quantity. Much of that is now altered; while some of the workers prefer to weave at home, and are permitted to do so, each large firm has a building of its own, where every process of the manufacture is carried on under one roof.

One of the difficulties which has attended the following of the poplin trade through its fluctuations of fortune has been that in all returns made of trade in Dublin, silk and poplin are includcd under the same head, and even in the census returns no distinction has been made between the weavers of different fabrics. With the commissioners a loom is a loom, but whether used for frieze, damask, cambric, fringes, silk, or poplin, has been a matter of perfect indifference. The same with Custom-house returns. Only that a personal knowledge of the poplin trade and its extent were sufficient to preserve conviction of its existence, we should have doubted it, for we failed in the most careful examination of the statistics furnished by Her Majesty's commissioners of the Board of Trade to find a trace of a manufacture which keeps upwards of 600 looms in constant work. An indus-

trious weaver can turn out about 2,000 yards per annum, and this, be it remembered, in weaving which precludes the use of the shuttle of ordinary hand weaving ; for the poplin shuttle is thrown from one side to the other by hand, from left hand to right hand, and from right hand to left hand again. The care which is thus bestowed on every inch of poplin is the secret of the beautiful equality of the fabric. With a special scissors every little roughness is removed from the surface of the web, though the warp has been previously most carefully picked free from the slightest scrap of floss.

In the manufacture of figured goods a wonderful improvement was effected in the year 1800 by the invention of M. Jacquard of Lyons, of a loom called after him the Jacquard, which superseded the employment of draw boys in weaving figured goods. Independently of the ordinary play of the warp threads for the formation of the ground of such a web, all those threads which should rise simultaneously to produce the figure have their appropriate healds, which a child formerly raised by means of cords that grouped them together into a system, in the order and at the time desired by the weaver. This plan evidently occasioned no little complication in the machinery when the design was richly figured ; but the apparatus of Jacquard subjects the manœuvre to a regular mechanical operation, and it derives its motion from a simple pedal put in action by the weaver's feet. It was generally adopted soon after its invention.

Those who have seen damask weaving in operation will have no difficulty in understanding the principle of the Jacquard loom. But it is not alone for texture that Irish poplins are remarkable, their colours have a softness and brilliancy peculiarly their own. Manufacturers of other fabrics have availed themselves as largely of the new aniline dyes, but not with the same results.

Colloquially the brilliant shades are ascribed to some quality in the water of Dublin, the same which makes Guinness' stout pre-eminent.

Our illustration above is of a loom in the factory of Messrs. O'Reilly, Dunne, and Co., which stands on Merchants' Quay, directly opposite to the Four Courts. Their warehouse is in College Green, a handsome new building, which cannot fail to arrest the stranger's eye.

Before the work has reached the stage represented in our woodcut, the material has been put through various processes. In one room is stored the raw silk in the stage in which it has come from China, from Italy, or from India. A most critical operation is the dyeing, in which the silk loses 25 per cent. of its weight. So much of the beauty of the poplin depends upon the dyer, that the greatest skill is necessary to produce the exact shade required. After being returned to the ware-room, twisted in thick hanks like coils of ladies' hair, it is wound on spools and given to the warper. By him it is taken off the spools, and put on a cylindrical frame called the warping mill, on which a certain number of threads of equal length are placed at equal distances from each other, the thread being drawn off as many as fifty spools at the same time. The threads are then put on a roller, whence they are drawn through a sort of comb (see illustration), in order that a surface may be arranged through which the weft—that is to say, the woollen yarn—may pass in the process in which the two constituents of poplin-silk and wool are united. After this the woollen yarn is thrown across the silk from hand to hand as described, into which it is worked by means of what is called "harness," which consists of six parallel laths, a number of which move upwards, whilst an equal number work downwards. The illustration will much simplify this description.

The iron work on the top of the loom is the Jacquard machine used for making figures and brocades.

The pattern is produced by wires operating in perforated revolving cards moved by a treadle in connection with the great harness behind which the weaver sits. The wheel to the right is not part of the loom. The woollen wefts (of which there are three pads in front of the baskets) are wound by this machine on quills for the shuttles. In the baskets there are some bobbins of silk ready for the warping machines. In the basket on the left there is also some white China silk, which costs in that state about thirty-five shillings per pound.

The Jacquard machine is not attached to the loom when plain poplins—not brocaded—are being woven. The woollen yarn for the weft is wound on the shuttles ready for the men by women, upwards of 200 women being constantly employed in this branch of the trade. It is light work, in no way injurious to health, but requires care, and a delicate sense of touch in arranging the little bobbins on which the yarn is wound previous to its transfer to the shuttles.

Messrs. O'Reilly, Dunne, and Co., have just filled an order for the Grand Duchess Marie, the future Duchess of Edinburgh. One dress is a morning one of tartan poplin, blue, black, and green, the Sutherland, or more generally known as the tartan of the 42nd Regiment, the same which three or four weeks ago left England for the Gold Coast. A beautiful soft brown of terry poplin, and another of deep violet; both these dresses are of dark shades. Of lighter colours, but of terry also, is a lavender, verging towards mauve, one of those indescribable shades which are a speciality of poplin; this is a dress which may be made either for morning or evening. A pearl grey, very soft and delicate in shade; and a blue, not azure, not peacock, not Danish, but—poplin-coloured. The greens produced by Messrs. O'Reilly, Dunne, and Co. are not the least remarkable of their colours. A few years ago, green, as a colour for a lady's dress, had fallen into disrepute, and was considered rather vulgar; but in the new hues the colour has taken in these poplins, all the old traditions respecting green dresses vanish and are forgotten. If desired, poplins can be watered, and will last much longer than the ordinary *moiré antique*, so long a favourite with ladies; but good taste generally decides in favour of the plain fabric.

Black poplin is a most economical dress to wear as mourning, and the new black just come into use, three times more costly than the old processes, is a deeper shade, far more intense when applied to poplin than can be produced in silk alone or in wool alone. Her Majesty the Queen patronizes one special make, to which Messrs. O'Reilly, Dunne and Co. have given the title of the Queen's black. It is a beautiful lustrous fabric and is corded —not exactly as the terry make, but with two cords alternately with a combination of silk threads. Both sides of the fabric are alike, and the cost is from about nine to ten shillings per yard. Double poplin costs about seven and sixpence, and single about five and ninepence a yard—a cheap dress, considering the intrinsic value of the material as well as its elegance.

The three kinds of poplin are made by all the manufacturers, but some make particular qualities, or peculiar shades, and others artistic designs, a special study.

Messrs. Pim, Brothers and Co., of William Street, Dublin, and Milk Street, London, E. C., have been most successful in every branch of the poplin trade. So far back as the year 1848, when the manufacture was at a most languid period of its existence, scarcely more than a retail trade, the Messrs. Pim boldly determined to strike out, and by going into a wholesale trade, particularly for exportation largely, to give a new impetus to the trade generally, as well as to their own house in particular. As a proof of their success, a list of the medals gained by them at exhibitions both at home and abroad requires no further comment. Dublin, 1850; London, 1851; New York, 1853; Paris, 1855; London, 1862; Dublin, 1865; Oporto, 1865; Paris, 1867; Dublin, 1872; Vienna, 1873.

The only other firm besides that of Messrs. Pim and Co. who exhibited at Vienna, were Messrs. R. Atkinson and Co., of College Green. They too received, and most deservedly, a medal "for merit." They exhibited single, double, terry-ribbed, figured, and brocaded poplin. The most beautiful of the whole collection were two pieces with white and with salmon grounds. Each coloured ground was brocaded and tissued with the Austrian eagle and shield in gold, and colours intended for a trimming round the dress or train, the upper or central part being brocaded with the monograms of the Emperor and Empress surmounted with a gold crown. The Empress's monogram was wreathed in white lilies, emblematic of purity. The Emperor's initial letters were surmounted by oak leaves and various emblems of strength. The quantity for a court dress of this poplin was valued at fifty guineas, and the sum is small when the character of the material is taken into consideration. No painting could be more delicate or more minute than was the pattern woven into this poplin. The design was of Hibernian origin also, being drawn especially for the Messrs. Atkinson at the Queen's Institute, in Dublin, one of the most valuable female training schools in the three kingdoms. Here women are taught, not only to draw designs, but to be lithographers, painters on china, printers, telegraph clerks, and teachers.

The late Alderman Atkinson, of Dublin, founder of the present house, was one of those who devoted the best energies and years of his life to the improvement of poplin weaving. This firm have a few looms at their place of business in College Green, but much of their work is done by the artizans at their own homes. It seems wonderful, in those dingy, not over clean houses in the Liberties, that the white poplins—purely white indeed they are —should be woven without a soil or spot. The white with a brocade done in pure gold thread made by this firm are real works of art. The Marchioness of Lorne and others of the Royal Family have each had several court dresses of the gold and white brocade, the cost of which is about twenty-two shillings a yard.

At the London Exhibition of 1851, the medal awarded to the firm of Messrs. Atkinson and Co. was adjudged in glowing terms as follows:—

"To R. Atkinson and Co., 31, College Green, Dublin, for poplins of excellent quality, rich in colour, and perfect in manipulation. There are some double and triple corded, of admirable execution. The figured pieces are of good design and brilliant effect. The specimen given of their weaving, by the presence of one of their weavers, who works at an elegant loom upon a rich and elaborate design, is highly interesting and instructive."

Contrast this with the tameness of the award to an English house for poplins which follows:—

"———— for poplins, plain, striped, watered, of superior make and excellent colours; the character of their manufacture is highly meritorious."

This was the testimony of skilled jurors twenty-two years ago, before the manufacture of poplin had attained its present position, and every year which has passed since has witnessed the introduction of numerous improvements both in style and texture, as well as in new combinations of materials.

Among the curious specimens of the work of which Ireland was capable, past as well as present, exhibited by (and now the property of) this firm at the Dublin Exhibition of 1853, was an excellent likeness of George the Second, in tapestry, woven in 1738, which once hung in the assembly-room of the Weavers' Hall. A quaint inscription beneath it showed the nationality of the workman:

"The Workemanſhip of John Vanbeaver
Yᵉ Famouſ Tapiſtry Weaver."

Though last mentioned, the establishments of the Messrs. Fry are not the least important of the manufactories of poplin.

There are two firms bearing names somewhat similar, namely, Messrs. Wm. Fry and Co., and Messrs. Fry and Fielding; and the heads of both firms are the sons of the late Alderman William Fry, who was one of those who assisted in establishing the poplin trade on its present basis. The Frys, as manufacturers, have been identified with the trade of Dublin for more than a century, and as both of the existing firms work on the same principles which gained for the old one its reputation, the praise awarded to the fabrics of one will equally apply to the other.

One hundred years ago the Coopers, of Markree Castle, Sligo, had a town-house in Lower Kevin Street, which stood in the midst of grounds of about three acres in extent. All this is now covered with the works of the Messrs. Wm. Fry and Co. Here, besides poplin, are made carpets, silk damask or tabourea reps, furniture trimmings and coach laces. Upwards of 400 hands are at work here every day. The trimmings which ornamented the state liveries of the present Lord Mayor of London only left the looms in Kevin Street in time to be worked up for Lord Mayor's Day. The design of the trimming of the hammercloth, the rose, shamrock, and thistle, conventionally treated in shades of oak on a purely white ground, was the work of an Irish artist.

Messrs. Fry and Fielding, who were originally members of the old firm, seceded from it, and are now carrying on the same trade on their own account. Their retail house is in Westmoreland Street—the Alexandra House; and their factory in the Combe, in the midst of the weaving district. There they have turned old premises belonging to the Earl of Meath into a spacious factory, and manufacture not only poplin for dresses, but rich brocatelles for coach trimming, and elegant borders for curtains. The figured terry tissue, intended for furniture, made by both these firms, is unequalled in texture and design, as well as colour, and is so wide as to need no joining, no matter how wide in breadth the curtain is required to be.

Among other Dublin houses engaged in the Irish poplin trade may be mentioned Mr. E. Moran and Messrs. Inglis and Tinckler, Eustace Street, Dublin, the latter of whom have also a branch establishment at 147, Regent Street, London.

For the last ten years ladies have been complaining of the deterioration in the wearing qualities of silk for dresses, especially in black silk, and this, too, with a considerable advance in the cost.

The price has increased, and the value has decreased. Our mothers could have bought a black silk dress for four or five shillings a yard, in which a lady might creditably have appeared in any society, and which, with care, lasted for two or three years.

Our grandmothers, for three or four shillings per yard, could have purchased the same quality, and it would give many years' wear. These silks, it is true, were of narrower widths than silk is now woven, but not so much narrower as to account for the increase in price, more than 50 per cent. in the last twenty years.

From seven to twelve shillings a yard is an ordinary price now, but even at the latter figure black silks are not the economical dresses they used to be. Some of them "cockle;" in others every crease becomes a sharp line, which the silk

retains. In some the warp is defective, and drops away in patches, leaving the weft semi-transparent; and in others, though more rarely, the weft disappears. In thin silks it is worse still, for little holes, about the size of pins' heads, appear simultaneously throughout the fabric, and not at the places where strain and the friction incident to wear can be pleaded as an excuse. The same thing may be observed in modern umbrella silks.

These remarks sum up the grievances of some ladies of whom inquiries have been made concerning their experience of the merits of the two fabrics, silk and poplin. In the latter, for from seven to twelve shillings, the double and terry poplins may be had, and a single one at five and ninepence a yard is far superior both in appearance and in durability to silk at the same price. The crease peculiar to silk is never seen, and the inner thread being of wool prevents the fabric dropping into pin holes. Where the friction of the sleeve of a dress in course of wear rubs away the silk surface of the part of the skirt with which it comes in contact, the front breadths of a dress are rendered comparatively worthless, it is the first indication of shabbiness. In poplin, by turning the other side of the fabric, the inner one will be found quite unimpaired by friction upon the upper, and in half-an-hour a lady's-maid can restore the dress to its original state of perfection. It is no exaggeration to say, that one poplin dress at seven-and-sixpence or nine shillings a yard will give wear equal to two silk dresses at the same price.

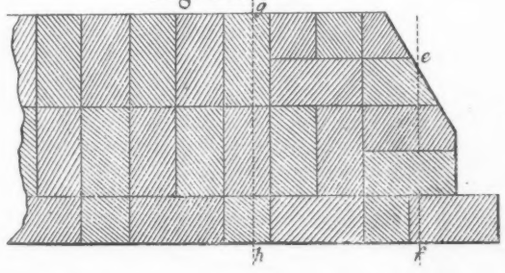
In conclusion, it only remains to call attention to the many fabrics which have had their origin in imitation of Irish poplin. The *droguets*, *reps*, and other similar textures which have been favourites in the fashionable world for many years, are neither more nor less than the application of the principle on which poplin is made to cheap materials, none of which, however, even in their pristine beauty, which is shortlived, can vie with the colours, durability, and general excellence of genuine Irish poplin.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(65.)

THE Student's Sketch-Book of Working Drawings.—In note No. 38, p. 387, the student will find the drawings of a square "reveal" in brickwork. In fig. 307 we give the plan of first course of a "splayed" reveal; in fig. 308 the plan of second course, all the other courses, to whatever height this part of the wall may be carried, being repeti-

Fig. 307.

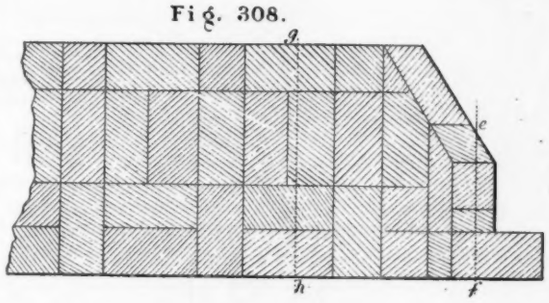


tions of these two courses, as shown in the elevations in fig. 309, the cross section on the line *e f* being given in fig. 310, and in the line *g h* (figs. 307, 308) in fig. 311.

(66.) **The Elements of Cabinet-making Design.**—In fig. 312 we give a centre-piece of an elliptical design with the centres marked; and in fig. 313 half of another design of the same character. In fig. 314 we give the drawings of a small "pier" table, of which A is the front elevation, B the side ditto, C plan, D enlarged drawing, showing moulding at edge *b* (in A) of table top; in E, full size drawing of part *a* in A. In figs. 315, 316, and 317 we give designs for inlaid scroll work.

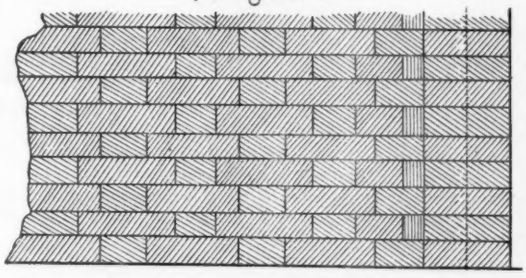
(67.) **The Development of Surfaces.**—In continuation of this subject, we now proceed to consider the solid known as the "pyramid," the development of the surface of which is useful in the setting out of the inclined surfaces of roofs, &c. A pyramid (see fig. 318), is a solid of which the base is a rectangular figure, as a square, as *a b c d*, fig. 319, or a parallelogram, as *a b c d*, fig. 321, and the sides of which are triangles, as *a b c*, *a d b*, fig. 318, meeting in a point or vertex, as *a*, common to them all. To develope the surface of a pyramid the base of which is square, as in fig. 319:—In this *a b c d* is the plan in A, fig. 319, and *g h i* in B, fig. 320, the vertical section of pyramid on the line *d e* of plan. At any convenient distance from,

Fig. 308.



equal and parallel to *a d*, draw the line *e f*, fig. 319, the height *j k* being equal to *l i* (B, fig. 320) *j e f* is a vertical section of the pyramid on the line *a b*, plan A, fig. 319. From *j*, with *j f*, describe an arc *f m*. With the distance of one of the sides of the base, as *a b*, set off in the arc *f m* to *n o p* and *m*. Join *j m*, *j p*, *j o*, *j n*, *j f*, and *j e*, and the base lines *f n*, *n o*, *o p*, *p m*. The

Fig. 309.



part *f n o p m*, *m j*, *j f*, is to be cut out with the knife, and the sides *j f*, *j n*, *j o*, *j p* half cut through. The four parts, *j*, *f*, *n*, &c. folded together till the line *j m* coincides with *j f*, will form a pyramid. The pyramid, as already stated, is used largely in the construction of roofs. We gave an illustration of a "hipped

Fig 310.

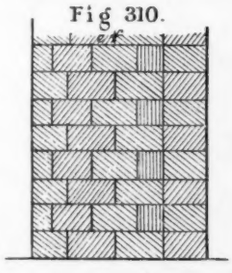
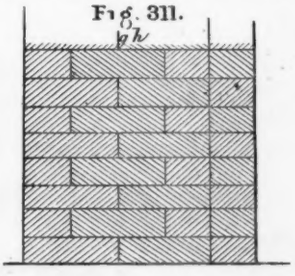


Fig. 311.



roof," which will show the application and the mode of developing its surface by projection as in fig. 321. In this the sides are trapezoids, the ends isosceles triangles. Both sides and ends are isosceles triangles. Let *a b c d* (fig. 321) be the plan of building. The length of the sides *a d*, *d c*, and the length *c f* of the ridge pole being determined, as also the angle of the pitch of roof, which in the example is 48°, bisect the sides and ends of plan, and draw parallel to these through the points, lines, as *g h*, *i j*, intersecting in *k* the centre of the roof in plan; produce *g h* to *l* and *m*, and *i j* to *n* and *o*. From the point *d* as a centre, on *d c* produced, describe with a radius of 60° the arc *o p*, and make *o p* equal in length to 48°. Join *d p* by a line cutting *f m* in *q*; *d q* is the length of the principal rafter. Produce *h d* to *r*, and make *d r* equal to *d q* by describing from *d* the arc *q r*, cutting *d r* in *r*. Draw *r s*, and from *e* and *f* draw lines parallel to *n o*, *f t*, *e s*; join *a s*, *d t*, which give the length of the hip rafters. From *a* and *b*, with distance *a s*, describe arcs cutting *g h* in *l*; join *a l*, *l b*; *a l b* is the end of the roof. Complete the other

side, *b o c*, and the other end, *c m d*. Cut through the card board on which we suppose the drawing to be made all round the boundary, beginning at *b* and ending at *l*, and half through the lines *a b*, *a d*, *d c*, *c b*; fold up the sides till the edges *s t* and *o* meet, and fold in the ends till the edges *d m* and *m t*, and *a l*, *a s*, meet, when the roof will be formed. The pyramids and their sectional angles are of great utility to the carpenter, joiner, and mason, in enabling him to find, not only as already named, the various coverings for hipped roofs, but also the wreathed portions of hand-rails, and the bevels of the beds of stones in arches, oblique arches, &c. &c.

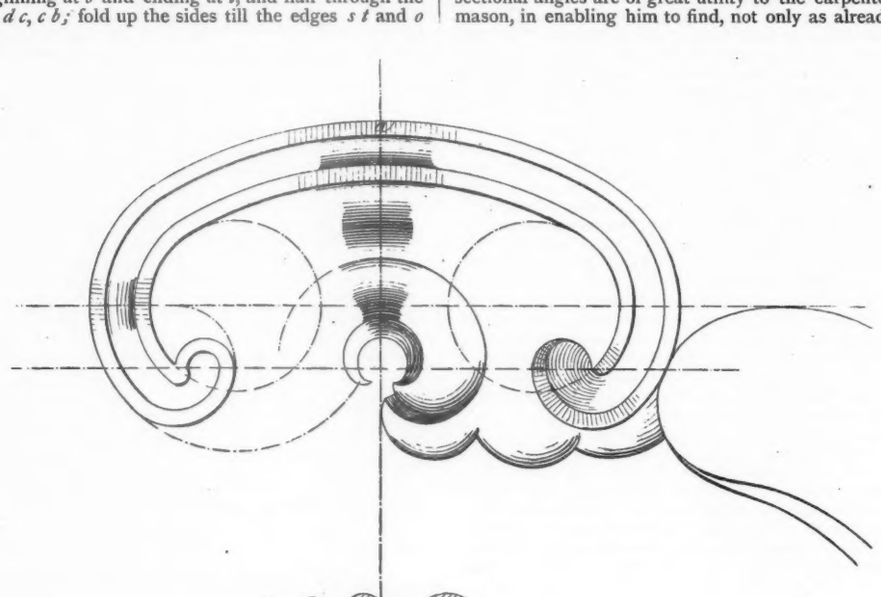


Fig. 312.

(68.) **To describe the Eccentric Curves, the Ellipse, Parabola, Cycloid, &c. &c.**—The curves known by the generic term the "eccentric," are of great use to the mechanical student, as by them he finds the forms of various parts of his design, the outlines of which are formed by these curves or portions of them. As to the methods of describing these forms, it may in many instances be remarked of those to whom they would be of great use in their avocations, that considerable ignorance prevails as to their principles and how they can be applied in practice. Not seldom have we seen in the workshop a gross ignorance of even the simplest of them, and had we asked many mechanics to describe—say for example, an ellipse or "oval," as it is generally and technically termed—a by no means small proportion of them would have been unable to perform the task, even when that involved the use

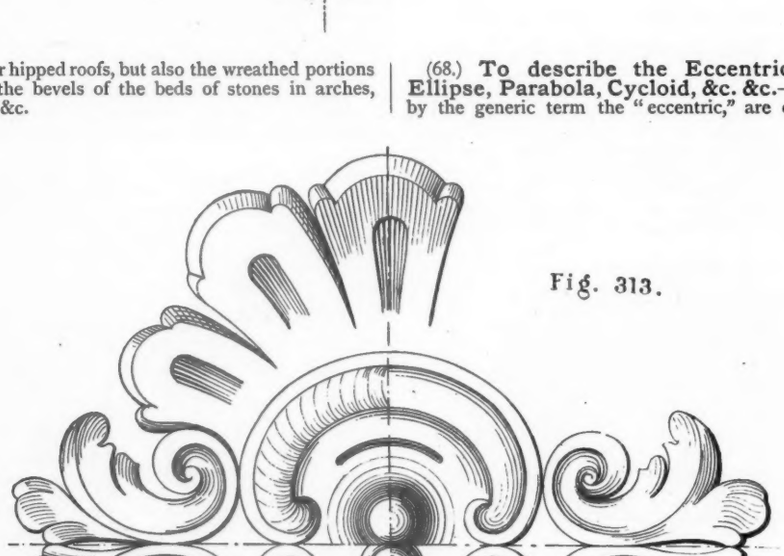


Fig. 313.

of the simplest method, or which we may call the conventional, to say nothing of those methods which give the true forms. We believe, therefore, that we are doing the student a service by performing the promise we made in a preceding note, to give the problems connected with the various eccentric curves. To begin with the "ellipse" or "oval," this is a continuous curve, which although circular in appearance, as in fig. 322, has no portion of it that of a true circle. Like the circle, however, it is a continuous running into itself, and is generated by a line having relation to two points called "foci," as *a b*, each one being singly

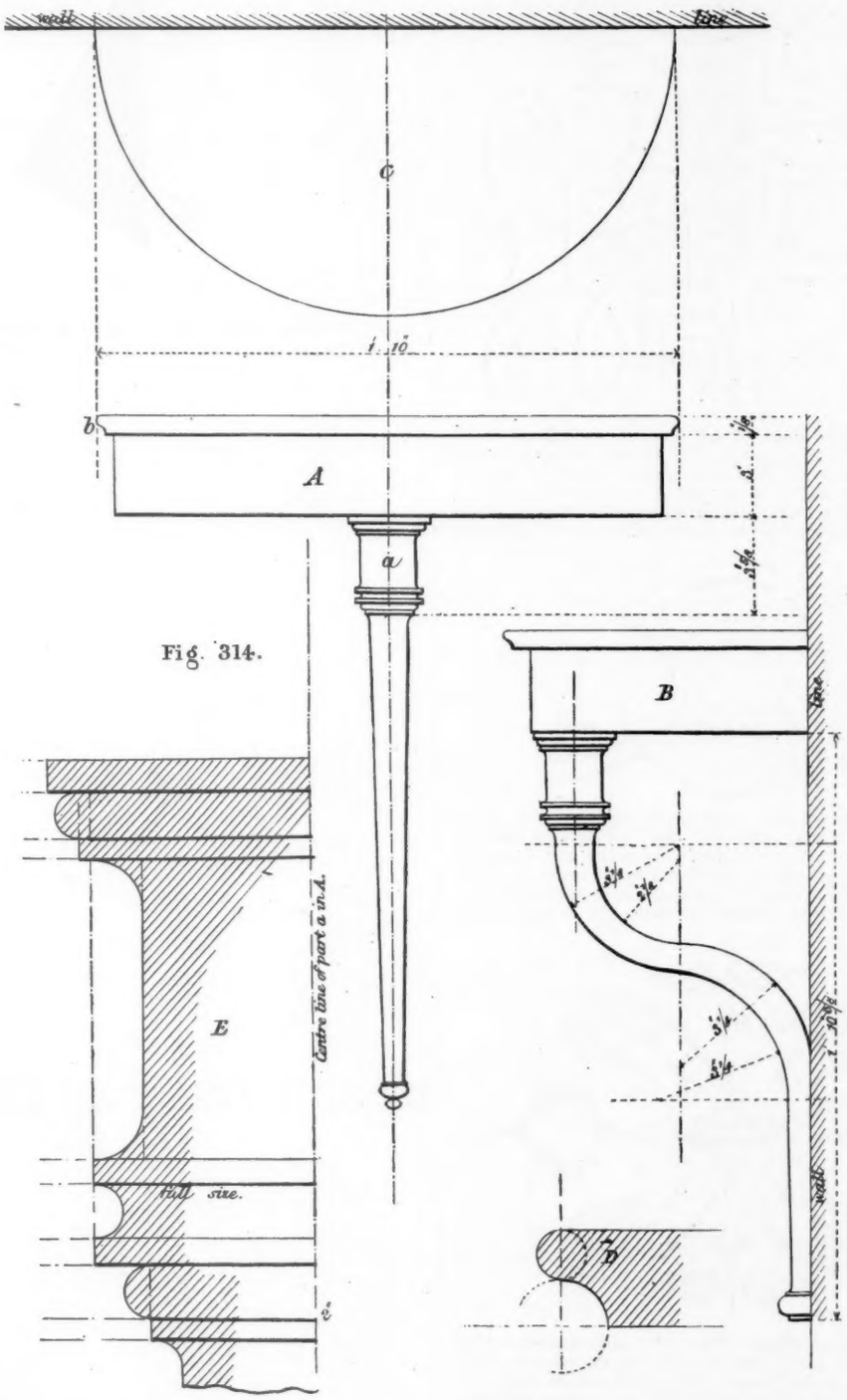


Fig. 314.

termed a "focus;" the shortest diameter, as *c d*, is called the "conjugate diameter," or "conjugate axis," this being situated midway between the two foci, and at right angles to a line, as *e f*, which passes through both foci, and is terminated by the curves at each end, as *e* and *f*. The longest line is called the "transverse diameter," or "transverse axis." All lines which are bisected by a diameter as the lines *i j*, *l k*, by the diameter *e f*, are called "ordinates" to that diameter; the part as *i* where the ordinate, as *j i*, touches the curve of the ellipse, is called the "vertex" of the ordinate. When an ordinate, as *k l*, cuts the

transverse diameter into two parts, the parts are called abscissa. The point *h* where the shortest, *c d*, intersects the longest, *e f*, is called the "centre" of the ellipse. The student, however, should not associate this in any way with the centre of a circle, the curve of which is generated round the centre, and is equidistant at all points from that centre. In the cone, the curve is con-

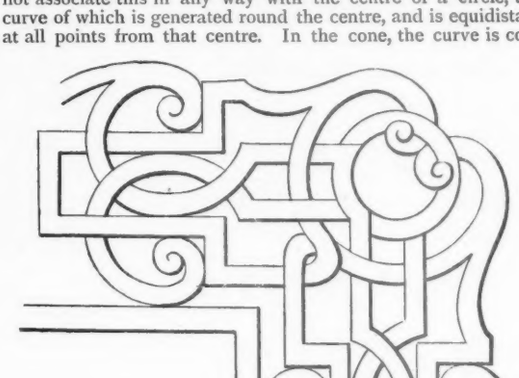
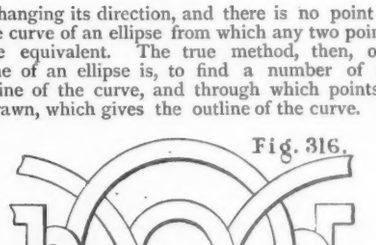


Fig. 315.

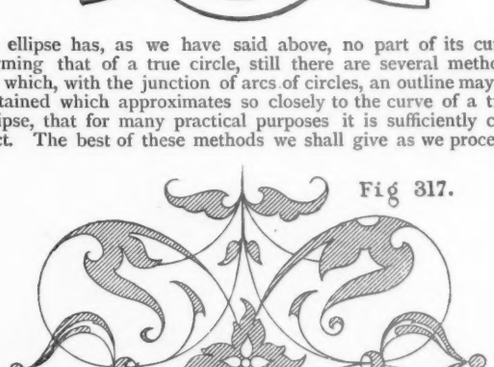
tinually changing its direction, and there is no point or centre within the curve of an ellipse from which any two points in that curve are equivalent. The true method, then, of finding the outline of an ellipse is, to find a number of points in the true line of the curve, and through which points a curved line is drawn, which gives the outline of the curve. Although

Fig. 316.



an ellipse has, as we have said above, no part of its curve forming that of a true circle, still there are several methods by which, with the junction of arcs of circles, an outline may be obtained which approximates so closely to the curve of a true ellipse, that for many practical purposes it is sufficiently correct. The best of these methods we shall give as we proceed.

Fig 317.



The true curve of an ellipse is that of a surface produced by sections of the two solids, the cylinder and the cone by lines which are oblique to their bases. Thus, if the cylinder in fig. 323 is cut by a line, as *a b*, parallel to its base, the section will have the outline of a true circle, the diameter of which will be equal to that of the cylinder. And as the cylinder has parallel sides, all sections at any number of points in its height, and all taken by lines parallel to its base, will be circles of the same diameter. But if the cutting line of the section be oblique to the base of the cylinder, as *c d* in fig. 323, then the surfaces produced will have curved outlines which will be ellipses, the length of the trans-

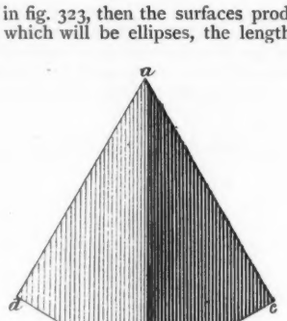


Fig. 318.

verse or longest diameter being equal to the length of the cutting oblique line, as *c d*. In the cone all sections taken through lines

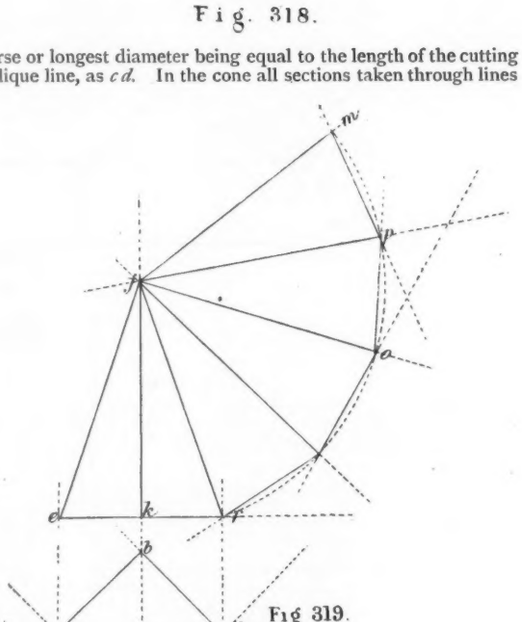
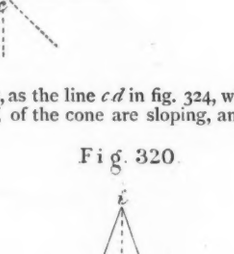


Fig 319.

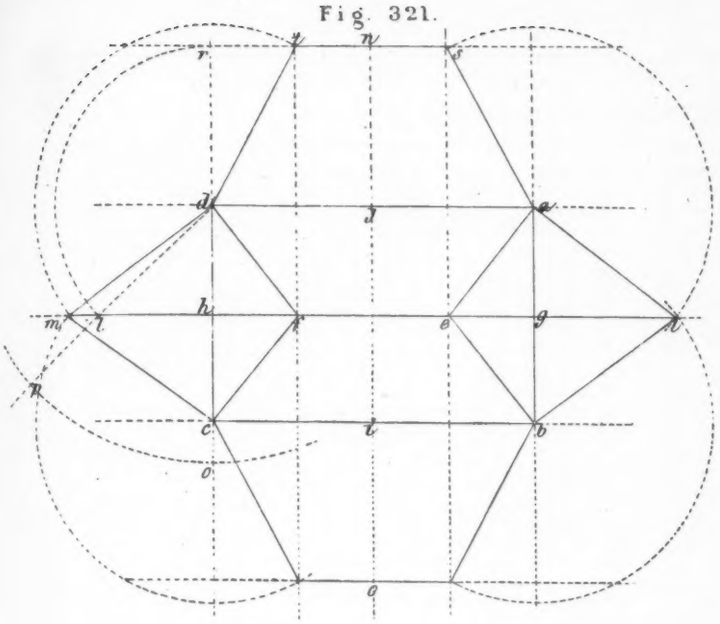
parallel to the base, as the line *c d* in fig. 324, will be circles ; but as the sides *a e*, *a f*, of the cone are sloping, and are continually

Fig. 320.



changing their distance from the central line *a b*, no two circles can be obtained of the same diameter, as in the case of the

Fig. 321.



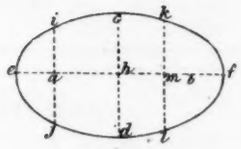


Fig. 322.

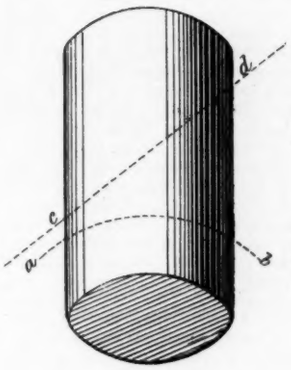


Fig. 323.

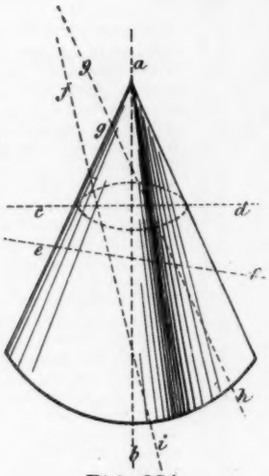


Fig 324.

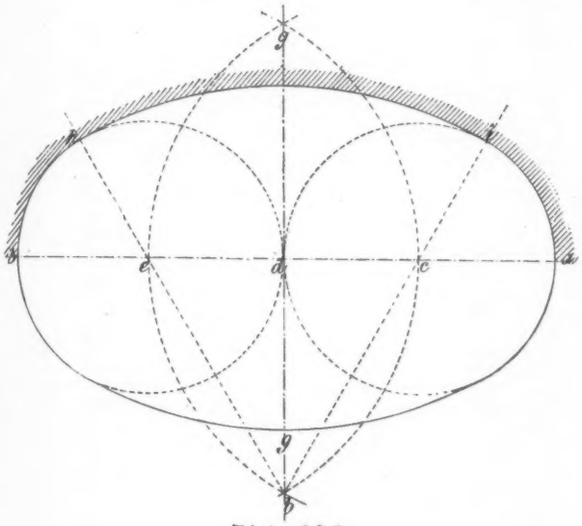


Fig. 325.

Fig. 326.

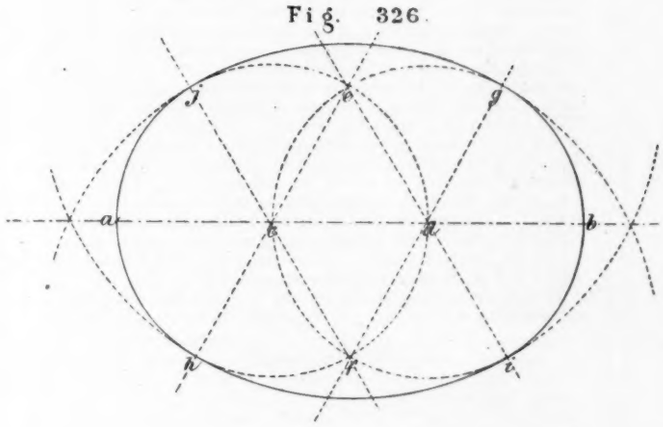
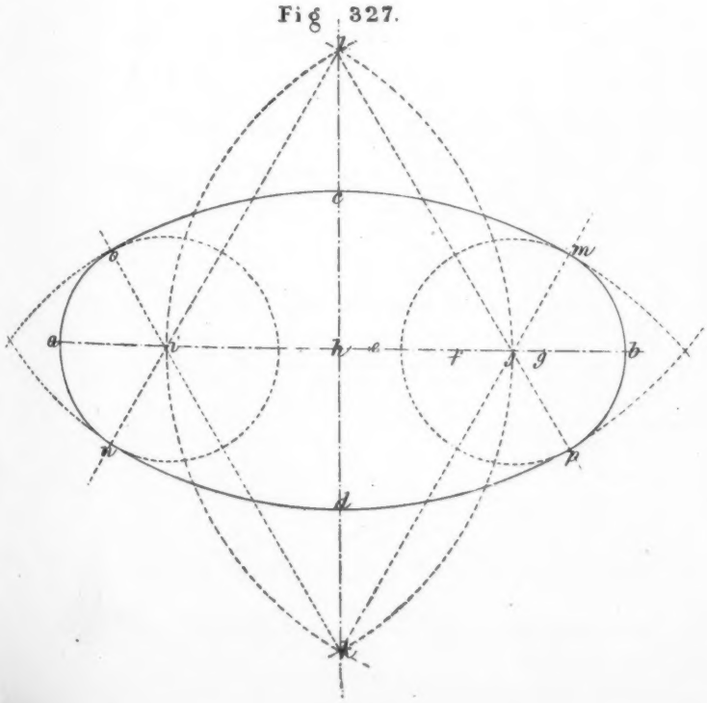


Fig 327.



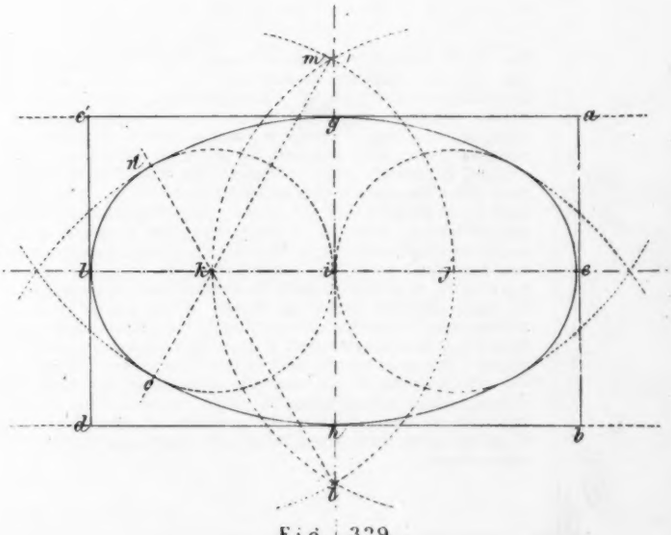
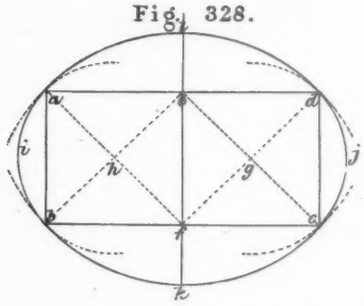


Fig. 329.

cylinder in fig. 323. But if the cutting line of section is oblique to the base, as the line *e f*, the surface produced will have a curved outline, which will be that of a true ellipse. The simplest, and what we may call the conventional or ordinary method of producing the curve of an ellipse, is by using arcs of *circles*. This, from what we have said above, will be seen to give merely approximate lines to the true curve; still as these for many purposes will be found sufficiently correct, we give a few of the methods based upon this system. In fig. 325 let *a b* be the length of the longest diameter, or what is called the "transverse diameter," *g g*, being the shortest or "conjugate." Divide the line *a b* into four equal parts, and through the second of them, as *d*, draw at right angles to *a b*, the line *g' d g*. From the points *c* and *e* the first and third points as centres, with radii *c a*, *e b*, describe circles *a c d*, *b h d*. Then from the point *c* and *e* as centres, with radii *c e* describe arcs as *g e f*, *g c f*, cutting in the points *g* and *f*. Then through the points *f* and *g* and the centre *c* and *e* draw lines as *f c i*, *f e h*, cutting the circles described from *c* and *e* in the points *h* and *i*. Then from the point *f* as centre, with radius *f i* or *f h*, describe the arc *h i*, joining the circles described from centres *c* and *e*; do the same from the point *g*, and the oval will be complete. Another method is given in fig 326, in which *a b* is the transverse diameter. Divide this into three equal parts in the points *c* and *d*; from *c* and *d*, as centres, with *c a*, *d b*, describe circles cutting in the points *e* and *f*. Through *d* and *f*, and through *c* and *e*, draw lines cutting the circles described from *c* and *d* in the points *g* and *h*, and through *c* and *d* a line cutting the circles *c* in the point *h i* and *j*. From the points *e* and *f* as centres, with *e h*, *f g*, as radii, describe arcs *h i*, *g j*. In the above two methods the two diameters have not been determined, only the transverse, as *a b*; in fig. 327 the two are determined, the "conjugate" *c d* as well as the transverse *a b*, the conjugate being larger than half of the transverse. Let *a b* be the transverse diameter, *c d* the conjugate. Take *c d* in the compasses, and set it from the point *a* to *e*; divide *e b* into three equal parts in the points *f* and *g*. With the distance of two of these, as *e g*, from the point *h*, where the two diameters intersect, set off to the points *i* and *j*. From *i* and *j* as centres, with *i j* as radius, describe arcs cutting in the points *k* and *l*. Through the points *k* and *j*, and *i*, draw lines cutting circles described from points *i* and *j* as centres with radii *c i*, *j b*, in the points *m* and *n*. From the points *l* and *k* as centres, with *l n*, *k m*, as radii, describe arcs *m o*, *p n*.

It may sometimes be required to describe an oval round a rectangle, as *a b c d*, fig. 328, the length of which will be twice

Fig. 328.



that of the breadth, or, in other words, round two squares. In this case describe the squares *a b f e*, *e f c d*, then draw the diagonals, as *e b*, *a f*, *e c*, *f d*. Then from the points of intersection of these diagonals as *g* and *h* as centres, with distances as *d g* as radii, describe arcs of circles as *i* and *j*; next from the points *e* and *f* as centres, with distances *f d*, or *f a*, as radii, describe arcs as *l* and *k*, joining *i* and *j*. Or it may be desired to describe an oval within the bounds of a rectangle, as *a b c d*, fig. 329; in this case bisect the ends *a b*, *c*, *d*, in the points *e* and *l*, and draw *e l* parallel to *b d*. Bisect *b c* in the point *g*, and draw *g h* at right angles to *e f*, intersecting in the point *i*. Divide the distance *e i* into four equal parts, the second of which is at *j*; make *i k* equal to *i j*, then from *j* and *k* as centres, with distances *j e*, *k l* as radii, describe circles as shown. From points *j* and *k*; with radius *j k* describe arcs cutting in the points *l*, and *m*, and from *l*, and *m*, through centre *k*, draw lines *l k n*, *m k o*, and from points *l*, and *m* as centres, with radius as *m o*, describe arcs *g n*, *h o*, which produced will meet the other circle described from centre *j*, which will complete the ellipse or oval. In a succeeding note we shall describe the methods of obtaining a true elliptical curve, these given being only approximatively true, as above stated.

THE CRITERION IN PICCADILLY.

THE growth of a great building in London excites very little surprise and not much attention now-a-days. It is an affair rather of a few weeks than of months; and passengers who come suddenly upon a clear space on a pavement where they have learned to submit to the inconvenience of a projecting hoarding, give a superficial glance at the reason for the obstruction having been removed, and then pass on.

It must be a very remarkable edifice, then, which attracts a small knot of gazers during the time that a great part of it is still incomplete, and before the unsightly hoarding is taken down; and for any building to continue to challenge public notice, it must possess remarkable characteristics.

That this has been the case with the very handsome structure just completed in Piccadilly, and known as "The Criterion," may be attributed, not only to the magnificence externally and the extraordinary completeness internally of the building itself, but also to the fact that it represents the outcome of a great enterprise. Even before the outer walls rose above the top of the timber screen, and when nothing was to be seen but the usual posters and playbills of an advertising station, "The Criterion" was a topic of conversation. Any adventurous street boy having discovered a forgotten chink, or knot-hole in the planks, and placing his eye thereto, could discern what an immense area it was designed to cover, extending laterally far beyond the site of the Old White Bear Inn, which had once occupied part of the space, and going back into Jermyn Street. People who had heard that this was the spot which had been selected by Messrs. Spiers and Pond whereon to show London what it had never yet seen, in the way of a great establishment, combining under one roof the whole art of luxurious living, asked each other why it was called "The Criterion," and the answer did not immediately follow. Not till the place was nearly complete did the title of the establishment seem to have a definite meaning. Neither Paris, New York, Vienna, nor Berlin, had yet accomplished the enterprise of providing in one stupendous building the means whereby a visitor might spend a long day, commencing with his morning paper, letters, and telegrams, and ending with his theatre, and *petit souper*. To accomplish this was the criterion proposed to themselves by the enterprising firm who had already revolutionized our whole railway refreshment system, and established elegantly appointed and admirably served station restaurants, in place of frowsy "eating-houses," or miserable bars, where everything was "flat, stale, and (as far as the consumers were concerned) unprofitable." Possibly the new establishment was also to be a criterion of the general desire to take advantage of such an opportunity to vindicate public taste, and if this were the case, the intention seems up to the present time to have been fulfilled. In fact the public taste may be said to have pronounced a favourable verdict even when the building itself could be only partially seen. When the noble central arched doorway rose above the top of the hoarding to the height of the second floor of the main structure, something was expected worthy of being the criterion of a great undertaking; and now that the entire establishment is completed, even to the last slab of parquetry in the magnificent assembly room at the top of the building under the central dome, and the last brilliant touch of colour to the bijou theatre in the basement, that expectation has been realized.

It is not easy to give more than a very general description of a building of this kind; but beginning by a glance at the whole edifice from the outside, one is struck by the excellent judgment which led the architect, Mr. Thomas Verity, of Northumberland Street, to select the style of the French Renaissance for such a building. No other kind of architecture would have been at once so imposing and so appropriate: for by adopting it, not only convenience of arrangement but tasteful variety of ornamentation have been secured.

As we have already remarked, the main entrance reaches to the second floor, the subsidiary entrances right and left corresponding to the two wings of the building, while sculptures and reliefs, with some elaborate architectural decorations, adorn the façade, and the upper storey is marked by four niches containing figures representing the seasons. Above this is a range of decorated windows, lighting the grand hall or assembly room; and the whole, including an attic and main cornice, is surmounted by a Mansard roof which, following the general lines of the façade, rises higher at the ends than in the centre. This roof is surrounded by a railing, so that it may be used as a summer promenade, whence extensive views may be obtained not only of London but of the surrounding country. The façade is of Port-

land stone, and the sculptural details are the work of Mr. Edward W. Wyon. The minor entrance in Jermyn Street is also of fine proportions, leading as it does to what is known as the "chop and grill room" (a department fully appreciated by hungry wayfarers), and to a vestibule whence a staircase communicates at once with all the other parts of the building.

It is at the great entrance in Piccadilly that the visitor is likely first to enter, however; and this at once admits to a vestibule 30 ft. long by 25 ft. wide, and of the height of the external archway. This vestibule, of course, forms the central means of communication with all the public rooms. The decoration here, as in most of the rooms, is of a novel kind, introducing, upon a scale which has hitherto never been attempted by the use of hand-painted glazed tiles, a material for mural decoration which is practically indestructible, and of which advantage has been taken for producing a cheerful and brilliant effect. These and all other painted decorations have been executed by Messrs. Simpson and Sons, the figure subjects having been painted by Mr. A. S. Coke. These tiles could only be equalled in effect by fresco paintings, and they possess the enormous advantage of being comparatively indestructible, and of retaining their clean bright appearance in spite of the London atmosphere.

From the vestibule access is obtained to the large dining saloon on the right hand, 80 ft. long by an average width of 27 ft. wide, and on the left to the magnificent refreshment buffet, at the south end of which is the smoking divan. The buffet is also approached from Jermyn Street, and has likewise a separate entrance from Piccadilly, where is situated the cigar divan and telegraph room.

The great luncheon hall, as it is the first to be seen, is, we think, the most representative portion of the building. The decorations are admirable, and the judicious use of low tones of colour give ample effect to the great space, and to the sense of height and perfect ventilation, which are so essential. It must be mentioned, however, that the means taken for lighting, for warming, and for ventilation are so successful that not the least distinguishing feature of the whole establishment is the absence of unpleasant glare, and the pleasant equability of temperature.

Turning again into the vestibule and ascending the grand staircase, we reach the east and the west dining saloons on either hand, both of which are sumptuously furnished and appointed. On this floor also are situated the ladies' ante-room and toilette-room. Perhaps no better impression is gained of the great extent and fine decorations of the whole building than in ascending this noble staircase, and pausing on the wide mosaic-paved balcony which forms the vestibule of the ball-room. The effects that may be obtained by the thoroughly artistic use of subdued tints, especially in conjunction with hand-painted tiles and marble, are here admirably displayed; while even in the ball-room the same avoidance of high colour and meretricious glitter is most satisfactory, in an apartment where eighty feet of length, fifty feet of width, and thirty-five of height, would make crowded ornamentation unbearable, especially as it is lighted not only by windows but by a dome thirty-five feet in diameter.

Near the ball-room and leading off from the grand staircase is a reception, or supper, room, as an adjunct to the ball-room. These, with lavatories and one or two small rooms, form the whole public portion of the upper building; the rest, with the exception of a few rooms in the attic, being devoted to culinary arrangements.

The entire harmony of the whole edifice may be indicated by the fact that the building generally is arranged in blocks, the service being placed so that the kitchens, serving-rooms, &c., are over each other, and situated in the centre of the building, immediately under the dining-rooms, for economy of service. The lavatories again form a distinct block, with the exception of the ladies' room, on the first floor.

For the daily service there are three distinct kitchens, each with its serving-room, larder, vegetable kitchen, and scullery. Some idea may be formed of the extensiveness of these kitchens from the statement that the roasting ranges are twelve feet wide. The steam hot tables are eighteen feet long and four and a-half feet wide, with hot plates extending around two sides of the kitchens, some heated by coal fires and some by gas, under which are numerous ovens for various purposes, specially ventilated and arranged to heat the whole to the required temperature by exceedingly small fires. There are also immense copper steamers, and fittings for cooking meat, fish, and all kinds of vegetables by steam, direct, or by the heat only from the steam, to suit the fancies of the most delicate palate. The fittings in the larder, vegetable kitchens, and sculleries are in one way at least—if all be true that is said of their construction—triumphs of ingenuity, having been so arranged that use will make them clean, instead of receptacles for kitchen and vegetable refuse. The wrought-iron screens enclosing the roasting ranges are of an entirely new construction, themselves forming hot closets, the workmanship of which is as neat as that of a first-rate bookcase. The great novelty, however, is a certain new patent smoke-jack, the fan of which is not in the flues at all, but in a receptacle in front of them—an ingenious plan by which the trouble and nuisance of taking the fan out to clean the flues is avoided, and oil vessels, &c. in the flues, done away with. The fan works vertically, and is not noticed. The condensed steam wastes, and wastes from the several fittings, are in cast-iron troughs, level with the floor, but with a moveable cover throughout their length, and with angle boxes and traps, so that all can be cleaned out in a few moments, and the trouble and expense, with stoppage in drains, bursts in pipes, taking up floors for repairs, &c., is avoided. The steam shelves of the hot closet, &c., are of wrought-iron, with a view to avoid the trouble of repairs from breakage by contraction and expansion, and being of the very latest construction, embody every improvement that the most recent experience in cooking apparatus has suggested.

The theatre, which will surely be one of the real attractions, is reached by a separate entrance on the right of the great vestibule, and is, in fact, below the level of Piccadilly—a fact which is not discoverable except from the pleasant fact that we go down an easy commodious staircase instead of climbing a difficult one—and return as easily without trampling on the trains of the ladies. This staircase is decorated with painted tiles and mirrors, and its landing contains convenient cloak rooms, while it terminates in an easily accessible refreshment buffet.

In the theatre also the ventilation and warming are thoroughly effectual, the former being attained by fans worked by machinery, and the latter in the same way as that of the whole building—namely, by forcing air through channels fitted with hot water coils, and conducting the warmed atmosphere by flues to every part of the structure. The means of egress from the theatre are declared to be so perfect that it can be emptied of the audience in three minutes, the way out being through completely fire-proof corridors.

As to the ornamentation of this charming little place of entertainment it is simply exquisite—the hangings of blue satin being relieved by white and gold decorations, and by curtains of amber satin, veiled with white lace. One can only speak of it as a bijou box, and yet it will accommodate 800 visitors, its "parterre" and amphitheatre stalls being spacious, and with a distinct entrance in Jermyn Street.

In a lower basement still we come to the real substantial mechanical part of the arrangements of this great building, to the two Cornish boilers and the vertical steam generator, where the steam for warming and for cooking is all under the control of the presiding engineer. This portion of the work has been completed by Mr. W. W. Phipson, C. E., and is another proof of the harmony and unity of purpose which are everywhere so obvious.

It may perhaps be mentioned that the fireproof construction throughout is supplied by Dennett and Co.; the water supply, hydraulic lifts, pumps, &c., by Turner and Co.; marble mosaic floors by Burke and Co.; parquetry floors by Arrowsmith, Steinitz, Oppenheimer, and Davenport; gas fittings by Verity and Sons, of Covent Garden; lavatories and sanitary fittings by Geo. Jennings and Co.; bars fitted by Sanders and Son; zinc-work by Holden and Co.: ornamental ironwork by Durenne, of Paris, Macfarlane and Co.; and Hodkinson and Co.; ornamental glass by Gould and Harold; mirrors by Commercial Plate Glass Company.

MORTAR of the Great Pyramid.—WALLACE gives the following analysis, showing that gypsum is the main ingredient :—

Hydrated sulphate of lime . .	92·83
Carbonate of lime	4·63
Carbonate of magnesia . . .	1·66
Alumina	0·24
Ferric oxide	trace
Silica	0·88
Hygroscopic water	0·07
	100·31

Chemical News, xxvii. 205.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

Influence of Sulphurous Acid on Plants.—SCHROEDER draws the following conclusions from his experiments :—

(1.) The leaves of trees absorb this acid from the air containing it, and carry it on to the other parts, the bark, the fibres, &c., either as such, or oxidized to sulphuric acid.

(2.) The absorption of sulphurous acid can be traced when the amount of acid in the air surrounding the leaves and branches is not more than $\frac{1}{5000}$ part of the volume of the air.

(3.) Under equal circumstances the leaves of pine-wood take up less acid than those of other trees.

(4.) The quantities of sulphurous acid absorbed by equal leaf surfaces give in themselves no measure of the damage which a plant may suffer through being exposed for some time to the influence of the gas. The specific organization of the plant must also be taken into consideration.

(5.) The absorption of the acid does not take place through the fissures of the leaf only, but uniformly through the whole of the surface. Under otherwise equal conditions, the same quantity of acid is taken up by the fissureless upper side as by the fissured under side of the leaf.

(6.) An equal amount of gas absorbed by the under side disorganizes the leaf in a much higher degree than the same quantity taken up by the upper side. This phenomenon is explained by the circumstance that the transpiration of the leaf chiefly takes place through the under side, and that the sulphurous acid exercises a specially noxious influence on the evaporation.

(7.) The destructive effects of the smoke and vapours of mines and factories upon plants may therefore be chiefly ascribed to the impeding of the transpiration through the sulphurous acid emitted.

(8.) Plants thus affected lose their capacity for normal transpiration, in consequence of which their organisms conduct less water than is required for their proper functions, and the plant in time perishes.

(9.) The disturbances of the transpiration vary directly with the quantities of sulphurous acid present in the air.

(10.) Presence of light, a higher temperature, and dry air, favour the absorption of the acid. It follows from this that the smoke and vapours of factories and mines effect more damage by day than by night.

(11.) The transpiration of pine-wood is not affected by a quantity of acid which injures a leaved wood. This corresponds with the lesser absorptive capacity of the former wood as compared with that of the latter.

(12.) In spite of what is stated in the preceding point, a pine-wood suffers more from an atmosphere containing sulphurous acid than a leaved wood. The probable reason of this is, that its needles most likely store up a quantity of the gas when exposed for a long time to it, whilst the leaved tree does not carry the effect of one year into the next. *Dingler's Polytech. Journ. ccvii.* 87.

[*Note by Abstractor.*—Point (10) seems capable of a very simple chemical explanation. It is well known that plants exhale oxygen under the influence of light ; this oxygen, which no doubt is in a specially active state, converts the sulphurous acid, which goes into the moisture of the leaf, at once into sulphuric acid, the effects of which are, of course, much more deleterious than those of sulphurous acid.

It may be worth while to test the question whether the treatment of trees in a factory district with showers of water would not somewhat lessen, or even entirely do away with, the destructive effects of the sulphurous acid. The water will partly wash away from the leaves the sulphurous acid solution, and by highly diluting the remainder will make its absorption of less severe consequence.—R. G.]

Caffeine.—R. WEYRICH gives a critical examination of the various processes proposed for the estimation of this alkaloid by Mulder, Peligot, Zöller, and Lieventhal. Of these he prefers Mulder's, which is as follows :—Coffee-berries are dried at 100° and powdered ; roasted berries require no drying, but simply pulverizing; the powder is then exhausted with boiling water, fresh water being used until nothing more is dissolved out after an hour's boiling with tea, three boilings of an hour each sufficing with coffee. The caffeine is evaporated to dryness on the water-bath after an admixture with calcined magnesia. The residue is powdered, digested with ether for some days, and filtered ; this treatment is repeated as long as the ether extracts anything. The ether is then evaporated off and the residual caffeine weighed. Chloroform is preferable to caffeine, as it dissolves caffeine more readily than ether. *Zeitschr. Anal. Chem. xii.* 104.

Borate of Lime.—A. W. CHASE states that a large deposit of this salt exists in the County Curry, on the northern boundary of California, on the slopes of the Red Mountain, about five miles from the sea. It was first found a quarter of a mile only from the sea, in the form of powdered masses, with corrugated sides and depressed tops, weighing about 200 lbs. each. The salt is very pure, being milk-white, and of a greasy feel.

Column 1 gives the analysis of a sample of hard borate extracted from a vein in a bed of blue steatitic rock, near its junction with overlying slate. Column 2 that of the softer borate occurring in isolated masses or boulders.

	1.	2.
Water	25·00	22·25
Lime	29·80	29·96
Chlorides	?	trace
Alkalies	trace	0·25
Boron trioxide	45·20	47·04
	100·00	100·00

Probably the origin of the substance is the conversion of a deposit of carbonate of lime into borate by the escape of vapours carrying boric acid with them, as in the Tuscany lagoons. *American Journal of Science* [3], *v.* 287.

Chalybeate Spring at Helmstedt.—FRESENIUS gives the following analysis of the water of this spring, which yields ten litres of water per minute :—

Temperature of water	15°
„ of air	11°
Specific gravity at 20°	1·0000381
	Per Mille by weight.
Sodium chloride	0·026189
Sodium nitrate	0·003126
Ammonium nitrate	0·000593
Potassium nitrate	0·011244
Potassium sulphate	0·004740
Calcium sulphate	0·017350
Basic calcium phosphate	0·000679
Aluminium phosphate	0·000021
Barium sulphate	0·000143
Strontium sulphate	trace
Calcium carbonate	0·006650
Magnesium carbonate	0·007440
Ferrous carbonate	0·018553
Manganous carbonate	0·000251
Silica	0·009183
Resinous organic matter	0·000389
Humus-like organic matter	0·003451
Total solids	0·110002
Carbonic acid combined as various bicarbonates	0·013956
Free carbonic acid	0·083968
Sulphuretted hydrogen	trace
Nitrogen	trace
Total constituents	0·207926

Although the iron present is actually small, the water has a strong chalybeatic action, owing to the comparative absence of alkaline salts, &c., interfering with its action. *J. Prakt. Chem.* [2] *vii.* 191.

Gypsum.—A. COSSA finds that gypsum facilitates the decomposition of the alkaline silicates contained in various kinds of rocks and soils, and hence exerts an important influence on the fertility of such soils. Comparative experiments on the solvent action of pure water and a saturated gypsum solution on various rocks gave the following results, the liquids being allowed

to stand in contact with the finely pulverized rocks at a temperature of 16°-22° for twenty days :—

1. Gneiss containing potash mica and orthoclase.
2. Decomposing trachyte (from Monte Chioja, Vicenza).
3. Undecomposed trachyte (from Monte Ortona).
4. Decomposing porphyroidal trachyte, containing mica and hornblend (from San Pietro, Montagnone).
5. Trachyte (from San Daniele).
6. Granite containing albite, quartz, and mica (from Montorfano, Lake Maggiore).
7. Granite containing orthoclase, quartz, and mica, containing a trace of lithia (from Baveno, Lake Maggiore).
8. White compact felspar (from Mosso, Brella).
9. Compact basalt (from Monte Nuovo).
10. Perlite (Monte Sieva).

	Dissolved out by pure water.	Dissolved out by gypsum solution.
1.	0·125 per cent.	0·463 per cent.
2.	0·094 „	0·256 „
3.	0·087 „	0·138 „
4.	0·057 „	0·093 „
5.	0·075 „	0·163 „
6.	0·073 „	0·207 „
7.	0·099 „	0·287 „
8.	0·350 „	0·714 „
9.	0·127 „	0·304 „
10.	0·062 „	0·198 „

Gazzetta Chimica Italiana, iii. 185.

Water from the Great Salt Lake.—H. BASSETT gives the following analysis of water from the Great Salt Lake, collected in August :—

Reaction.	Slightly alkaline.
Specific gravity at 17°	1·102
Solid residue	13·67 per cent.
This solid residue consisted of—	
Chlorine	7·36
Sodium	3·83
Potassium	0·99
Calcium	0·06
Magnesium	0·30
Sulphur tetroxide	0·88
Other substances not determined	0·25
	13·67

Chemical News, xxviii. 236.

Ash from Vines.—J. NESSLER has examined the wood of various vines manured with different substances, with the following results:—

1. Not manured at all.
2. Manured with gypsum.
3. „ „ sulphate of potassium.
4. „ „ chloride of potassium.
5. „ „ mixture of chloride of potassium, superphosphate, and sulphate of ammonia.

SAMPLES TAKEN FROM THE NODES.

	Ash.	Nitrogen.
1.	3·38	0·62
2.	3·69	0·79
3.	3·32	0·75
4.	4·33	0·95
5.	2·89	0·72

SAMPLES TAKEN FROM THE INTERNODES.

	Ash.	Nitrogen.
1.	2·89	0·60
2.	2·80	0·72
3.	2·62	0·62
4.	2·90	0·91
5.	2·51	0·41

COMPOSITION OF ASH—SAMPLES FROM NODES.

	Phosphoric Acid.	Potash.	Lime.
1.	9·45	16·98	30·16
2.	8·43	17·20	23·29
3.	7·76	22·99	26·25
4.	9·85	22·30	23·68
5.	12·06	22·89	30·99

SAMPLES FROM INTERNODES.

	Phosphoric Acid.	Potash.	Lime.
1.	9·02	16·76	25·66
2.	8·99	20·72	21·92
3.	7·34	23·25	23·99
4.	10·48	24·45	20·40
5.	12·02	24·58	30·17

The highest amount of ash hence was with No. 4. No. 5 gave a less percentage of ash, but a much larger total growth of wood. *Landw.-Versuchs Stationen, xvi.* 185.

§ 2. *Metallurgy.*

Pure Iron.—Absolutely pure iron may be produced by means of the galvanic battery. During the process a large quantity of hydrogen is disengaged from the ordinary iron used as positive electrode. The pure iron is a silver-white metal, very malleable and ductile, and so soft as to be readily cut with a pair of scissors. It is very different from iron which has heretofore been supposed to be pure. It oxidizes very rapidly, and water is decomposed by it with rapid absorption of oxygen.

Burnt Iron.—E. SCHOTT ascribes the so-called "burning" ("Anbrand") of cast-iron to the unequal regelation point of the various compounds of iron and phosphorus, sulphur, carbon, silicon, or manganese, in consequence of which some portions solidify whilst others are yet in the liquid state, and thus in contracting squeeze out the liquid portions.

[*Note by Abstractor.*—This supposition, which *prima facie* appears very probable, could easily be tested by analyzing such heterogeneous portions of the ingot.—R. G.]

On the Cracks and Fissures occurring in Large Ingots of Cast-Iron and Steel.—F. VON EHRENWERTH attributes these to the unequal expansion of the cooling mass. To prevent their production it is recommended:—

(1.) To heat the moulds before running the molten metal into them.

(2.) To give the ingots to be cast as much as possible a globular shape.

(3.) To select for casting such raw material as will show on cooling great ductility. *Dingler's Polyt. Journ. ccvii.* 56.

[*Note by Abstractor.*—The paper contains nothing new, excepting suggestions (2) and (3), of which the last is a piece of charming *naïveté*, for it amounts to the advice that only iron of good quality should be worked up.—R. G.]

Manufacture of Manganese, Ferro-Manganese, and Spiegeleisen.—On behalf of an inventor, whose name is withheld, great improvements in the manufacture of manganese are claimed by which this metal, now employed in the making of steel and the higher qualities of wrought-iron, may be produced in a condition pure, or nearly so, without melting, and used in the manufacture of ferro-manganese and spiegeleisen in a manner producing a better quality of product, in less time, and at less expense than by the old processes. The process consists in a thorough mixture of pulverized oxide of manganese ten parts, and three parts of solid carbon, such as coke or charcoal. These ingredients are inclosed in metallic or earthen cases, large enough for the desired charge, and having the opening temporarily closed with a metallic sheet, or covering of earth, to prevent the admission of air while allowing the escapement of gases. These cases are charged in an ordinary furnace to a bright red, barely yellow, and are subjected to this heat for twelve or fifteen hours, according to quantity. In the process, the carbon unites with the oxygen and passes off as carbonic acid gas, and gives as a product nearly or quite pure manganese. To secure spiegeleisen the pig-iron is melted, and about 12 per cent. of the manganese is charged into it and melted. The proportion of ingredients is run off when melted into ingots, as spiegeleisen, when it is used in the ordinary way. Ferro-manganese is produced by charging a greater per cent. of manganese into the molten pig-metal—say 25 or 30 per cent. The manganese counteracts red-shortness in the steel, apparently by uniting with the free oxygen or metallic oxides which may be in the steel, being particularly useful in the manufacture of boiler plate steel.

Claim 1. The reduction of manganese in close boxes, or cases, in a suitable furnace at less than a melting heat, with or without the introduction of iron. 2. The manufacture of spiegeleisen and ferro-manganese by charging the unmelted, or metallic, manganese produced, as set forth, either in boxes or in blooms, into pig-metal previous to or after melting. 3. The charging of metallic manganese, either in cases, or blooms, into a bath of molten steel, substantially in the manner set forth.

The inventor considers his process will be most valuable to those using an open hearth steel-melting furnace, such as the Siemens, as it has been for a long time a great desideratum to obtain a pure metallic manganese, especially in manufacturing the softer grades of steel, such as roller plate, tank plate, &c. He claims that the use of ferro-manganese conduces to the life of the furnace, because when rails are desired containing from ¼ to ½ of one per cent. carbon, the bath of molten metal has to be run down in carbon as low as wrought-iron, otherwise when

the spiegeleisen is added the percentage of carbon will be higher than desired, and also adding some silicon, which is injurious. It is well known that a much greater heat is required to keep a bath of molten metal liquid, containing no more carbon than wrought-iron, than when it contains about ½ per cent. carbon. It has also been proved that a furnace making steel that never runs lower in carbon than ¼ per cent., lasts from three to four times as long as one that runs the steel down to wrought-iron. Therefore it is cheaper to use manganese or ferro-manganese than spiegeleisen. *American Manufacturer.*

Improvement on the Siemens-Martin Steel Process.—The Siemens-Martin steel process consists essentially in first melting a quantity of pig-iron to form a "bath," and subsequently adding to this bath wrought-iron or steel scrap, which has previously been heated to redness. It is evident that the product in this process is dependent on the purity of the materials employed, particularly the pig-iron. James Park has patented a process whereby he produces steel in a similar way to the Martin process, but, using only substances of great purity, the product is a steel of the best quality. He takes blister steel containing say one per cent. of carbon, and melts it in a crucible. When melted, an equal quantity of wrought-iron, previously heated, is added, and a steel obtained containing 0·5 per cent. carbon. This addition of wrought-iron may be continued even to the point of the formation of soft iron, if desired. The process may, of course, be performed equally well in an open hearth furnace. Although the patent bears the date of 1867, it has only recently been published. *Iron, October*, 1873.

Iron in Nova Scotia.—Some very promising beds of iron ore have been exposed near Whycocomagh, Cape Breton, and some deposits of great promise have been found in Hants County. The ore is identical in character with that of Londonderry. A vein of copper ore has been discovered at Holson's Lake, Nova Scotia, of some extent and value.

Antimony.—A discovery of antimony in the ranges at the head of Spring Gully, Sandhurst, Australia, has recently been announced, and it is expected that a promising lode of the mineral named will soon be laid bare. About eighteen years ago, when miners were prospecting in that neighbourhood for auriferous quartz, they met with enormous bodies of quartz with, however, little or no gold in it. They, however, found a substance which was thought to be block mundic, but which it now appears was antimony. In the bottom of a shaft sunk to a depth of nearly 130 ft. they came upon a body of the antimony running along and forming a solid wall about a foot thick. Being troubled with the water, the shaft was, however, abandoned. In the course of years the shaft was partly filled in, and the workmen dispersed to various parts of the country. One of them subsequently worked in the antimony mines of Costerfield, where he remembered the old "block mundic," and it struck him that it would pay as well as the antimony of Costerfield. Some months since he returned to the old ground, and took it up under a miner's right. A few of his friends have since co-operated with him, and they have obtained a lease from the Government of thirteen acres. They are now cleaning out the old shaft referred to, and are confident of soon coming on the solid body of sulphide struck there so many years ago. Patches of it are seen in an old cross-cut running west from the shaft, at a depth of 70 ft.

Tin Plate.—T. S. SPEAKMAN gives the following details of the manufacture of tin-plate as carried on in Wales :—

The manufacturer usually prefers making his own iron to purchasing it, because he can thereby insure a more equable quality ; he therefore buys suitable pig-iron.

For common coke tin-plates, the iron bars are made from puddled iron. The puddled ball is sometimes squeezed and sometimes hammered ; much depends on the care of the puddler in bringing forward his ball so that all its parts shall be equally decarbonized, when the fracture will be of a uniform dull grey colour, without crude admixtures of bright crystals. The unreduced crystals produce "wasters" of the iron plates, and if any such escape the notice of the mill manager, the wasters are thrown aside again after being covered with tin. If they escape the eye of the assorter, the tin-plate worker will find them fracture across the angles or bends of the sheets in working them up. The puddled ball produced under the best conditions is then taken to the shingler, who submits it to the squeezer or hammer, sometimes both. This operation should be carefully executed. As the puddled ball is rugged and full of cinder, the cinder has to be squeezed out by this operation, and at the same time the roughness must be so managed as to be welded into a solid compact mass, which cannot be so well done in after operations. Some say it cannot be done afterwards, as the whole mass can never again be brought up to a thorough welding heat throughout, unless at the expense of much waste and loss. The bloom from the shingler is at once passed through the rolls, or roughed down into No. 1 bar. Some prefer letting the blooms lie exposed to the action of the elements for a time, and others think it of no importance. The bar, while hot, is cut into lengths and piled, five pieces being put and heated together in the balling or reheating furnace. When the faces are brought up to a welding heat, and the whole mass softened, it is again taken to the hammer —some rolling at once, others returning the bloom into the furnace, to again bring up the heat. It is then rolled out into the finished bar, of suitable size and thickness for the kind of plates required.

Some manufacturers made very good iron from the puddled ball direct, saving in wasters and improving the quality ; but as the labour and number of hands were reduced by this mode, the men struck against it, and spoiled their work if not well looked after. This kind of iron is homogeneous, and not fibrous, as the iron "piled" and brought through the reheating furnace. The shingler must be very careful to form a second bloom under the hammer, and the bloom should be upset once or twice, so as to secure a welding of all the rough edges. If, after the shingling, the bloom has lost too much heat, it should be reheated. Care and expedition will remedy that necessity, and the reheating furnace may be dispensed with altogether. The saving in cost and waste is great, but the trouble with the workmen is also great. Some also produce very excellent iron from the puddling furnace by adding to the charge about 60 lbs. of scrap or shearings, the trimmings of the plates when cut to size. The 60 lbs. of shearings are thrown into a bath of saturated solution of nitrate of soda, and added to the charge during the boiling. The advantages gained are—the scrap iron improves the charge in the proportion it bears to the whole mass ; it is melted down quickly without waste, as the smelting takes place under the surface. The weight of solid cold iron takes it to the bottom of the charge, carbon is eliminated by fusion with the nitrate, and the quality of the charge is thereby improved. The ball is treated in the same way as ordinary puddled balls afterwards. The iron is tough as charcoal iron, with the characteristics of puddled iron, arising from crudities, for crystals unreduced are not exterminated though greatly reduced. A careful puddler can at all times prevent these crude lumps to a very great extent. Another saving arising out of the process is that the scrap shearing formerly put into a furnace and reduced to a welding state, hammered out and rolled, gives only a return of 13 cwt. to the ton, whereas the other returns the full weight of the shearings. However, difficulties with the union men occurred.

The bars are cut up into the required sizes, brought to a cherry-red heat in a reverberatory furnace, rolled out to a certain length by gauge, doubled, and returned to the furnace, re-rolled, again doubled, heated and re-heated. The several foldings of the sheets adhere slightly.

After the sheets are cut down to size for tinning they are separated from each other by what is called opening ; during the process of opening, "stickers" and imperfect plates are thrown out and the passed sheets then go into the pickling room. There they are put into a hot pickle of dilute sulphuric acid, to be cleansed from oxidized and silicious matters, and undergo another rough examination in the scouring process ; that is, any plate not cleansed is rubbed with sand in water. Defective sheets are again thrown out, and the sheets or plates are now passed into the annealing room.

The annealing furnace is a large reverberatory furnace capable of holding several annealing pots. The pot is composed of a stand of a sufficient size to take the sheets, with a raised rim. Several hundred sheets are piled on the stand, and a square, box-shaped cast pot completes the pot. This is inverted over the sheets, and the space between the rim of the stand and the rim of the inverted pot is filled with oxide of iron, to lute it down and exclude the air. The pots are then put into the furnace until it is full, and the whole brought up to a cherry-red heat, or a little beyond. About eight hours' heating is necessary. When removed from the furnace they are slowly cooled in a place free from draught, and then the pots are opened. The plates never lie perfectly flat, and should be of a dark straw colour at the edges. If the air should get in in small quantities, a deep blue colour will cover the sheets more or less. The plates adhere slightly, and are again separated, when they are ready for the second pickling. The plates are again submitted to a hot but more dilute pickle of sulphuric acid, and chemically cleansed ; taken from the acid bath, they are well washed in running water, and kept in clean water until the tinman is ready for them.

The tinman takes the plates from the water-bath (where they lie some hours) and plunges them wet into a bath of hot palm oil called the grease-pot. When they have acquired the temperature of the grease-pot, they are removed with tongs and quickly sub-

merged in a bath of tin. The oil from the plates floats at the top, forming a flux which covers the melted tin and prevents oxidation. With the tongs, the sheets or plates are continually kept moving and separated, to insure the tin getting between all of the sheets. When the bath has recovered its heat, which it generally does in about half an hour, the tinman examines the charge, and if he finds that perfect union has taken place between the two metals, he removes them with a tongs to the next bath, which is kept at a low temperature.

The temperature raised by the change from the "tin-pot" is again allowed to cool down to a few degrees over the melting point of the tin, when the plates are taken in lots of a dozen or two at a time, and laid on an iron slab which is at the side or head of the pot. The waste metal and grease run back into the pot, the slab being inclined. The workman then takes up sheet by sheet with the tongs, and dips each into another bath of fine metal kept at a heat a little over melting point, immediately withdraws it, and places it in a rack immersed in a large pot of melted palm oil kept at the proper temperature, where they are allowed to remain a certain time. The sheets are then slowly lifted out of the grease by a boy, who separates them into proper lots by counting carefully, regulating the intervals of time between them. The grease recoils from the top plate, and, as little is left on the sheets, they are again placed in a rack in the open air to cool; when cool a lad takes each sheet in a tongs, and dips the lower edge into a small bath of melted tin, so regulated that the sheet can only enter to about the eighth of an inch. It is kept long enough to melt off the drops of metal which adhere to the lower edge, and when lifted the sheet is struck to throw off the superfluous metal from the edge. The plates are again put into a rack, and taken while warm to a bin of bran, where each sheet is thrust into and under the bran, to get rid of the grease which adheres. It is then passed on to a second and third bin kept filled with new bran. The sheets are turned out covered with flour dust and bran, and dusted off with cotton shaggy cloth.

The next process is in the sorting room. Here the finished sheets are laid on tables, and each sheet undergoes an examination by the sorter, who throws out those shearings which are defective in the iron or trimmings. The latter are reheated to regain the tin; the imperfect sheets are sold as "wasters" at a less price; the sheets are counted, and the box of 100 lbs. weight is composed of 225 sheets of 14 in. by 10 in. for home use or for exportation. *Paper read before the Franklin Institute, Philadelphia.*

Alloy inalterable in the Air. — JACOBI patents the use of the following composition :—

Copper	from 70 to 73	parts.		
Tin .	„ 9	„	11	„
Lead .	„ 15	„	20	„
Zinc .	„ 0·5	„	1	„

Bull. de la Soc. Chim. Paris, xx. 426.

Copper Solder for Candelabra, &c.—OUDRY patents the use of a cement made of resinous, bituminous, or gummy substances, and finely divided copper (produced either by galvanic action or fusion); this cement can be used for repairing objects electroplated with copper, such as cast-iron chandeliers, &c.; at the ordinary temperature it is solid, but liquefies by heating or by the application of a hot iron. *Bull. de la Soc. Chim. Paris, xx.* 428.

Soldering Lead Pipes lined with Tin. — BELGRUND proposes to remedy the inconvenience occasioned by the melting of the more fusible inner coating of tin during the soldering-up of joints, and the consequent production of obstructions, by plunging the end of the pipe in a sand-bath heated to 227°; the tin then melts and runs out, leaving the outer shell of lead intact for a short space. *Revue Scientifique, November, 1873, p.* 479.

Annealing.—The change produced by annealing is not well understood. Most of the malleable metals assume two distinct forms : one crystalline, which is the result of slow cooling, and the other fibrous, which is brought about by hammering or rolling. If hammered or rolled beyond a certain point, the metals become so hard that they cannot be bent without breaking. If annealed beyond a certain point, the metals become crystalline. Thus, zinc may be drawn into a very flexible and tenacious wire; but if kept in boiling water too long it resumes its original brittleness, and displays a crystalline appearance when broken. The particles of the metal change their arrangement without altering the external form, and this change may be brought about in various ways; thus, brass wire loses its tenacity by exposure to the fumes of an acid, and even by air acting on its surface in a damp atmosphere. Hence it is necessary to preserve wire, such as is used in the manufacture of pins, in a dry air or under the surface of water. *Iron, October,* 1873.

Cornish Metalliferous Veins.—MOISSENET concludes from his observations, that where the inclination of the vein is little removed from the vertical, there the vein is richest. Usually a gangue or matrix of some hardness surrounds the vein, and is in most cases parallel thereto. The disposition of the richer lodes depends on the stratigraphical system prevailing in the course of the vein. *Comptes Rendus,* 1873, *September* 1.

Mineral Products of Upper Burmah.—G. A. STROVER reports that there appear to be good grounds for supposing that *gold* exists extensively in Burmah, though but little mining is at present carried on. In the Mogoung districts the gold-fields were stated by an Australian (Golding) to be equal to any in Australia, if not better. In the Shan states, north-east of Mandelay, also, extensive gold-fields exist; but unfortunately both of these neighbourhoods are highly malarious.

At Thayet-pein-yua, near the Myit-Nyay, on the road to Pyoumgshoo (S. E. of Mandelay) quartz reefs crop up in abundance; at Sagaing, Kannee, Sein-joo, in the Yaw district, gold exists in alluvial deposits, and it is also procurable from the Kyeend-ween River, and indeed from the sands of most streams between Mandelay and Mogoung.

Silver is found in many localities in the Shan states, especially at Bawyine, Kyouktch, and Toungbyne, near Theebaw (N. E. of Mandelay). The ore is a very richly argentiferous galena. Other mines also exist, such as the Baudween, Baudweengyee, and Sagaing. Silver is found in some towns unmixed with lead.

Copper occurs abundantly in the Shan states, but is not worked; also in the province of Yunau. The Sagaing mines were at one time worked by the Chinese, but are now abandoned, the surface ore not being promising. At Bawyine and Koleu-myo a rich malachite is found.

Iron abounds in the Shan states and in the district of Pagan, south of Mandelay, where a rough manufactory exists at Pohpah Toung. West of Sagaing, up the Irrawaddy River, a rich hematite abounds for miles. Machinery is now being imported from England to be erected at Sagaing, for the purpose of smelting this ore. The surface hematite alone will supply the wants for years to come.

Lead is found plentifully in the Shan states as galena; but little, however, is extracted, there being no great demand. Some also comes from Yunau.

Tin is found in the Shan states, S. E. of Mandelay, but is not worked, the metal used in the country being all imported.

Platinum is said to exist in the Shan states, and *graphite* is found in large quantities to the east of Nat-taik, on a low range of hills near the village Nyoke-toke; it is not utilized, however.

Coal is known to exist in several places, Thingadaw, Shuaygoo, below Bhamo, Meimbaloung, in the Yaw district, and east of Nattaik. Some of the beds are only lignite, but at Meimbaloung a true coal is found. All seem of considerable extent.

Jade and Amber are found above Mogoung. The quality is good, and considerable quantities are extracted, but the mines are capable of much development.

Sulphur occurs as efflorescent salts and as sulphides, plentifully, but not in the free state. It is extracted by roughly distilling the ore in earthen pots. Pyrites is found abundantly in the Shan states and other parts of Upper Burmah, but is not utilized.

Saltpetre is largely manufactured in twenty-three different places. In many places the ground is well supplied with nitre.

Rubies, Sapphires, and Garnets, &c., are found at Mojouk, Kyat-pyeen, N. E. of Mandelay. The gem sand occurs at from three to fifteen feet below the surface. Rubies the size of pigeons' eggs are said to be plentiful. They also exist in several other places.

Salt. Extensive salt-fields exist at Shimpagan, on the west bank of the Irrawaddy.

Petroleum occurs, as is well known, at Yegnaygyoung and Pagan. About 150 wells are worked at the former place, yielding about 9,375 tons per annum, the total yield of Upper Burmah being 10,312½ tons per annum.

Marble and Limestone abound, whilst the vegetable products are most prolific. Indigo, paddy, wheat, cotton, cutch, grain, sesamum, sugar-cane, tobacco, tea, coffee, teak, india-rubber, &c., are obtainable in abundance. *Chemical News, xxviii.* 187.

Minerals of Queensland.—The gold exported in 1871 amounted to 171,942 oz., of the value of £619,160. The gold-fields are situated at intervals along the range dividing the waters flowing to the east coast from those trending westerly;

from the southern boundary of the colony to latitude 15° S., or over 14° of latitude. An exploring party recently penetrated to some distance inland north of 14° latitude, and discovered several rivers, on one of which—the Palmer—gold was found for a continuous distance of 60 miles. Coal is also found in abundance, associated with iron, from the south boundary to latitude 20°, or over 9° of latitude, and strong indications of it were found by the exploring party in the territory mentioned above.

The principal points where coal is available for shipment are the Logan River, 27° 40′; the Brisbane River, 27° 30′; the Burrum River, 55° 10′; and the Styx River in Broad Sound, 22° 20′. At present only the Brisbane River and Burrum River mines are worked on the coast, and the Allora mines near Warwick. The Tivoli mine yields soft coal, the bed being 4½ ft. in thickness, and the present depth from the surface 350 yards. The coke producible on the spot from the small coal raised from this mine amounts to 600 tons weekly. Besides, there are the Bingera mine on the Burnett River, the Rosewood, 31 miles from Brisbane, the Aberdaire, 5 miles from Ipswich and 4 miles from the navigable Bremer River, and the Flagstone Creek, 49 miles from Ipswich; cannel coal may be had from Blackfellow's Creek.

Iron ore is obtainable in the form of a kind of brown hematite, on a spur of a range on the north side of Flagstone Creek, at an altitude above the coal of 40 fathoms. The seam is 16 in. thick, and has every appearance of permanency. There is also a good bed of limestone several feet thick, and suitable for smelting purposes, about three miles nearer to Helidon than the coal mines at present opened. Brown hematite is also found at Bandamba Creek, a few miles from Ipswich, close to a coal-field, two miles from a bed of limestone, and a short distance from a navigable river. Red hematite occurs about six miles from the navigable Bremer River, and is also near to coal and limestone, and chrome-iron ore is found in close proximity to the Brisbane River, where it crops out in mighty boulders for 200 yards, striking from E.N.E. to W.S.W.; this is one of the largest deposits in the world of this ore. There are also supplies of manganese, bismuth, sulphide of antimony, cinnabar, galena, &c.

Copper is found in the same districts as gold; a large number of copper mines have been recently opened up. Mercury has been found in large deposits at the head of Mary River, latitude 26° 30′, longitude 52° 30′, and also on the Clarke River.

Tin is abundant in the district of Stanhope, which occupies an area of about 30 square miles, the centre of which is in latitude 28° 45′, longitude 149° 50′. It is also to be procured at the head of the Burdekin—latitude 18° 30′, longitude 131° 10′.

Sapphires, opals, and diamonds occur, whilst timber trees available for commercial purposes are very plentiful. *Iron, October*, 1873.

To give Brass a Steel-blue colour.—The article is laid in a leaden vessel containing hydrochloric acid, to which some arsenic has been added, when it soon acquires iridescent colours. The brass is removed and washed when the desired shade has been produced. *Dingler's Polyt. Journ. ccviii.* 466.

§ 3. *Dyeing, Calico Printing, Tanning, Bleaching, and allied subjects.*

Finishing of Cotton and Linen Goods.—It is proposed, instead of simply sprinkling the goods with water, to introduce into the finishing mixture some hygroscopic salt, calcium chloride, for instance. The material so prepared is then hung for four hours in a cool room, when so much moisture will be absorbed as to render the goods fit for calendering. The mixture most recommended is one consisting of 100 quarts of paste and 3 ounces of calcium chloride.

For the sprinkling operation, various methods have been proposed. Sometimes the stuff is moistened with water and then put in a centrifugal machine; or the material is treated with steam at a low pressure. The process specially advised is to let a rotating brush, after it has passed through water, force itself past a metal plate, when the bristles in rebounding will spurt their moisture in a fine rain. *Dingler's Polyt. Journ. ccix.* 78.

Iron Solution for Calico-Printing.—A. KIELMEYER says that by carefully regulating the dry distillation of wood, a product may be obtained, which easily yields an iron liquor of constant quality. The usefulness of ferrous acetate as a mordant depends chiefly on a proper admixture of ferrous and ferric salts, and it is therefore proposed to employ a liquor containing a certain amount of tarry matter, which by floating on the surface and thus forming a layer, prevents the excessive oxidation of the iron on the cloth.

The quantity of iron in a sample of liquor is determined by evaporating a known weight, say 10 grammes, to dryness in a weighed dish, heating the residue with some nitric acid, and weighing the calcined substance as ferric oxide. Hydrometric determinations are not reliable, on account of the presence of tarry matters. *Dingler's Polyt. Journ. ccviii.* 439.

Methyl-green.—This derivative of rosaniline was, like all its congeners, formerly prepared by treating a rosaniline salt with the iodide of an alcohol radical. At present, however, the production can be more economically effected by directly oxidizing methyl-aniline. The substances thus obtained differ from those manufactured by means of iodine in their not being able to resist the action of daylight; they retain their colour only in artificial light, and are designated as "methyl" violets. The "methyl" green is prepared by acting with chloride of methyl on "methyll" violet. It dissolves with greater readiness in water, much more than the analogous iodine product, and the aqueous solution may be boiled without suffering decomposition. The tints produced are of great freshness, and wool can be dyed with methyl green without requiring further operations. *Dingler's Polyt. Journ. ccviii.* 466.

Indigo.—C. W. SMITH adopts the following process for the extraction of indigo from plants containing that dye. The leaf colouring substance (chlorophyll) and other substances not containing indigo are first separated by boiling or infusing the leaves or other parts of the plant in a solution of carbonated alkali of the strength of about from ½° to 1° B. Instead of the abovementioned alkali, other solvents that will act in an analogous manner may be used. The solution so obtained contains no indigo, and is therefore run off; the residuum left is then subjected to a boiling alkaline solution of from 2° to 5° B. It is preferable to employ a mixture of lime in the proportion of 10 per cent. of the weight of the dry leaf, and when the mixture is at the boiling point to add a suitable quantity, varying from 1 to 3 per cent. of the weight of the dry plant operated on, of stannous chloride and protoxide of zinc. The boiling is continued till the whole of the indigo is extracted and dissolved, which may be ascertained by an examination of the treated plant. The solution so obtained is then drawn off into suitable vessels and thrown down and collected in the usual manner and dried off for sale or use. The process can also be successfully applied to the spent plants or the residuum thereof after they have been submitted to the usual process for extracting the indigo contained in them, but which after such process will be found to contain a small amount of blue, owing to the imperfect operation of the ordinary process. It is asserted that by using this process the operation of extracting the indigo is performed more economically and efficiently, and in a shorter time, than by the old process, whilst the product obtained is of an uniformly superior quality. In the use of indigo it has been an ordinary practice hitherto to employ woad in the ordinary dye vat when woollen or other fabrics are dyed. As a substitute for woad, from which comparatively little colouring matter is extracted, it is proposed to use the indigo plant as imported in a dried state, and to prepare it for use by subjecting it to heat and grinding it into a powder.

Mordant in lieu of Tartar in Wool-dyeing with two Salts.—MALFAIT employs the following mixtures:—

No. 1.	Alum	10 kilogs.
	Water	10 litres.
No. 2.	Oxalic acid	3·5 kilogs.
	Water	20 litres.
No. 3.	Acetic acid	2 kilogs.

These three liquors are then mixed together, producing a mixture which only costs 0·16 franc the litre, or about half the price of the ordinary tartar bath.

Cochineal Dyeing.—Powdered cochineal is boiled for fifteen minutes with the above mordant liquor, diluted with water in the following proportions:—

Mordant liquor	4 litres.
Cochineal	1 kilog.
Water	20 litres.

The whole is decanted and the residue boiled with the same bulk of water, this operation being repeated, and the last liquors reserved for special tints. The bath is then prepared with two salts and the above cochineal liquor, and the wool worked at 70° until dyed to the required depth of shade; if the tint is

yellowish a little fustic is added to the bath; if too red, a little ammoniacal cochineal.

For crimson, ammoniacal cochineal is used—

Powdered cochineal . .	1·6 kilogs.
Mordant	6·4 litres.
Tin liquor	2·0 „
Water (in three batches) .	120·0 „

Fustic Dyeing.—The bath is prepared with fustic, mordant, and tin salts simultaneously—

Fustic	50 kilogs.
Water	500 litres.

These are boiled together for one hour. The mordant employed is the same in quantity as that used for cochineal; for every 10 kilogs. of wool, 2 litres of tin salts and 4 kilogs. of fustic are used.

Tin Salts.—The liquor referred to above as tin salts or tin liquor is prepared by dissolving 10 kilogs. of tin in a cold mixture of 40 litres hydrochloric and 20 litres nitric acid. *Bull. de la Soc. d'Encouragement, August*, 1873.

Tin Salts for Dyeing.—BRONNER prepares a pure substance free from iron and sodium chloride (which are injurious for scarlets) as follows:—Stannous chloride, free from iron, is digested in a porcelain basin with its own weight of pure fuming hydrochloric acid; this mixture is then diluted with twice its weight of boiling water, and chlorate of potash introduced into the hot solution in small successive portions, with continual stirring. The stannous chloride is thus transformed into the stannic compound without the evolution of chlorine as long as any stannous chloride remains unaltered. The addition of potash chlorate is stopped when the clear solution begins to turn yellow and to send forth free chlorine. About 90 grains of chlorate are required for 1 lb. of dry and pure stannous chloride. *Dingler's Polyt. Journal, ccix.* 77.

Disorganization of Cotton and Vegetable Fibres by certain Oxidizing Agents.—PAUL JEAN MAIRE finds that when cotton or linen fibres are moistened with chromic acid or a mixture of a chromate and an acid, or with permanganate of potash, no alteration in the tenacity, &c., of the fibre is noticeable after thorough washing, but the tissue is rendered much more susceptible to the action of alkalis, which weaken its strength much—the more so the stronger the lye. An ammoniacal solution containing only 1-10th per cent. requires a long time to produce the effect, but weakening of the strength of the fibre is still perceptible even with this dilute liquid. An alkaline solution of the oxidizing agent will also produce the effect, as will also an alkaline ferrocyanide, though not to so great an extent. Not improbably the injury sometimes done to bleached goods by soaping or washing several times arises from a reaction of this kind; the *rationale* of the weakening of the fibre appears to be that the oxidizing agent forms some new substance (either by oxidation or dehydrogenation), which is disorganized by alkalis. *Bull. de la Soc. Mulhouse, August*, 1873, *p.* 334.

The process for converting the colour of goods dyed with chromate of lead from orange to yellow also notably weakens the fibre. *Ibid. p.* 350.

Dyeing Kid Gloves.—REIMANN states that the gloves are stretched over a wooden hand and the colour is spread upon them with a brush. The following prescriptions are given:—

Black.—The glove is washed in alcohol and three times brushed over with a decoction of logwood, allowing between each brushing ten minutes for drying; afterwards dipped into solution of iron protosulphate and then brushed with warm water. Should the colour not prove sufficiently dark, a decoction of quercitron may be added to the logwood decoction. Instead of the protosulphate, some nitrate of iron may be used. As the leather begins to dry it is rubbed over with talc powder and some olive oil, and pressed between flannel. The treatment with talc and oil is repeated and the glove then allowed to dry on the stretch-wood.

Brown.—The solution is made up of varying quantities of decoctions of logwood and Guinea-wood. For darkening, a small quantity of iron protosulphate is employed.

Russia-red.—Decoction of cochineal with a tin salt and some saccharic acid, and, if a dark tint is demanded, addition of some logwood extract.

Grey.—Brushing with decoction of sumac and subsequent treatment with a feeble solution of iron protosulphate. Addition of logwood and yellow Brazil wood to the sumac decoction produces a greenish-grey tint.

The aniline colours can be employed without any previous preparation of the leather.

The blueish tinge so greatly liked in black gloves is obtained by washing the finished article with salammoniac solution.

If it is required to keep the seams white, they are covered with flour-paste with which some fat has been admixed.

Instead of brushes one may sometimes use a sponge. *Dingler's Polyt. Journ. ccvii.* 85.

Colour Designs on Leather for Bootmaking, &c.—HESS patents the use of processes which are identical with those in ordinary use for cleansing the hides, dyeing them, impression of designs by graining tools, &c., and finally currying: this operation is to be performed *after* the impression of the design. *Bull. de la Soc. Chim. Paris, xx.* 432.

So-called "Chemical Carbon."—C. KOECHLIN mixes lampblack with sulphuric acid of 66° B., and then submits it to repeated washing. This prepared lampblack can be easily suspended in water and so admixed with printing colours. On drying at 115° to 120° C. a sample lost about 5 per cent. of moisture, and then contained—

Carbon	80·25
Hydrogen	1·75
Oxygen	14·12
Lime sulphate and silicious ash .	3·88
	100·00

This "chemical carbon" is easily attacked by fuming nitric acid. Submitted to this treatment, and after washing digested with caustic soda lye, a residue of carbon is left which is in a highly divided state. *Dingler's Polyt. Journ. ccvii.* 76.

Preparation of White Lead.—WEISE states that white lead manufactured by the German method is greatly superior as regards colour and "body" to the Dutch and French articles. The word "body" designates the power of the colour to be opaque in small layers. The process prevailing in Germany consists in conducting acetic acid and water vapour into a chamber in which thin sheets of lead are suspended, and afterwards introducing air and carbonic acid. The advantage of this process consists in its being easily regulated. The normal constitution of white lead is regarded as a molecular combination of two molecules of lead carbonate with one of hydrated lead oxide, $2\,PbCO_3 + PbO\,H_2O$. If the amount of carbonate exceeds the proportion demanded by the above composition, the white lead is said to possess little "body." If the white lead contains some finely divided metallic lead, it appears of a greyish colour; yellow or reddish coloured specimens owe their tint to the presence of anhydrous lead oxide.

The following figures show the composition of white lead of various qualities:—

No. of Specimen.	Lead Oxide.	Carbonic Acid.	Water.	Quality.
1	86·80	11·16	2·00	Best
2	86·24	11·68	1·81	Second, still very good
3	86·03	12·28	1·68	Third, still good enough
4	84·69	14·10	0·93	Residues, bad
5	83·47	16·15	0·25	Abnormal, useless
6	93·70	5·31	0·90	Absolutely useless

The colour of the last specimen is obviously due to anhydrous lead oxide, for, calculating from the known combining proportions, we see that the carbonic acid and the water present can bind no more than 38·06 of lead oxide, leaving thus the large amount of 55·64 per cent. in the red state. *Monatschr. des Gew.-Ver. Cöln.*

§ 4. *Food and Sanitary Matters.*

Preservation of Yeast.—The yeast is well washed with cold water, and dried, first by simple pressure, and then in a centrifugal machine. It is afterwards placed in a vessel over calcium chloride, the air of the vessel is rarefied, and dry air or carbonic acid is passed under gentle heating over the yeast. The dry powder thus obtained, when kept in hermetically closed vessels, may be preserved for a considerable time without showing any sign of decomposition. *Dingler's Polyt. Journ. ccviii.* 467.

Extract of Meat.—A. EBERT gives the following analysis of various kinds of meat extract occurring in commerce:—

"Organic matter A" refers to that portion of organic con-

stituents soluble in alcohol at 80 per cent. "Organic matter B" to that portion insoluble therein.

1. From Fray Bentos, Uruguay.
2. Prepared by Benites, Buenos Ayres.
3. „ Tooth, Sydney, Australia.
4. „ San Antonio, Texas.
5. „ Harras and Schrade, Clinton, Texas.
6. „ Tourtelot, Chicago (sold as concentrated flesh essence).
7. „ Tourtelot, Chicago (sold as concentrated flesh extract).
8. „ Tourtelot, Chicago (sold as solid flesh extract).
9. „ Vorden, Elgin, Illinois.

		1.	2.	3.
Water		19·343	20·000	18·563
Organic matter	A	57·047	58·321	56·688
	B	0·829	0·836	0·624
Inorganic ash		22·781	20·843	24·125
		100·000	100·000	100·000
Nutritive value		79·828	79·164	80·813

		4.	5.	6.
Water		18·979	20·550	28·500
Organic matter	A	58·989	56·605	37·063
	B	1·045	1·200	27·312
Inorganic ash		20·987	21·645	7·125
		100·000	100·000	100·000
Nutritive value		79·976	78·250	44·188

		7.	8.	9.
Water		22·594	19·188	20·250
Organic matter	A	46·375	7·187	17·406
	B	23·250	57·000	54·500
Inorganic ash		7·781	6·625	7·844
		100·000	100·000	100·000
Nutritive value		54·156	13·812	25·250

Chemisches Centralblatt.

Fray Bentos Meat Flour.—A. POTT gives the following analysis of the residue left after extract of meat is prepared from flesh :—

Water	10·48
Fat	12·42
Albumenoids	72·06
Ash	4·88
	99·84
Nitrogen	12·01
Matters soluble in water	6·18

The ash had the following composition :—

Oxide of potassium	1·99
„ sodium	1·33
Lime	8·79
Magnesia	1·16
Ferric oxide	5·80
Phosphoric anhydride	15·33
Sulphuric „	0·82
Silica	0·66
Chlorine	0·31
Sand	53·33
Carbonic acid and loss	7·48
	100·00

Fresh beef gives much more ash, containing much more potash and chlorine. The main soluble constituents of meat are therefore absent in this so-called food. *Landw.-Versuchs-Stationen, xvi.* 193.

Hard Boiled Peas.—ROTHAUSEN finds that some kinds of peas remain hard on boiling in distilled water, whilst others become soft and pulpy. On analysis the following numbers were obtained :—

	Hard.	Pulpy.
Phosphate of lime	10·41	10·77
„ of magnesia	16·55	8·14
„ of potash	37·43	59·74
Sulphate of potash	14·80	8·10
Chloride potassium	6·23	4·72
Phosphoric acid	—	4·43
Potash	11·47	—

The cause of the hard boiling is the presence of large quantities of potash not combined with inorganic acids ; this decomposes the phosphates of the alkaline earths, which then form hard, horny compounds with the legumin of the grain. *Polyt. Centralblatt*, 1873, 142.

New Source of Starch.—Successful experiments have been made in France on the utilization of the flour of the bulbs of *Fritillaria imperialis*. The bulb of a two years old plant weighs half a pound, and yields about 23 per cent. of a white, soft starch, the mode of extraction being the same as that employed in the case of potatoes. In order to render this starch fit for food, it is washed, first with water alone, then with water containing 2 per cent. acetic acid, and finally with pure water. *Polyt. Centralblatt*, 1873, 69.

Bloch's Farinometer or Feculometer.—CLOEZ reports on the use of this instrument as follows :—A glass tube is employed, the lower part of which is 0·22 metre long and 0·016 metre diameter, the upper part being a cylinder 0·18 metre long and 0·028 metre in width, with a glass stopcock at the top. 10 grammes of pure starch placed in such a tube in contact with spring or river water absorbs moisture till it occupies 17·567 cubic centimetres. If this volume be measured off and divided into 100 equal parts, each degree of graduation will represent 1 per cent. of dry starch, 10 grammes of substance being taken for examination ; hence the quantity of dry fecula contained in a given sample can be readily determined. 10 grammes of substance are introduced into the tube along with some water, and agitated so as to break up aggregated lumps ; the solid particles in the upper part are then gently washed down to the tube at bottom ; the whole is then set aside for an hour or two until the starch ceases to swell, and fills the tube so fairly that it does not move when the apparatus is placed in an inclined position ; the volume occupied is then read off. If 76 graduations are filled up by the starch, 76 per cent. of dry fecula, and hence 24 per cent. of moisture, is present. Starch containing more moisture than this, balls together when handled. *Bull. de la Soc. d'Encouragement*, 1873, *No.* 230.

Tea and Coffee.—RABUTEAU states, in opposition to ROUX (*vide* "Practical Magazine," December, 1873, p. 441) that the effect of doses of tea and coffee is to *decrease*, and not to increase, the elimination of urea from the body. Eustriades obtained the same result.

The use of 15 grammes of tea daily for five days diminished the urea excreted by nearly 7 per cent. of the average quantity eliminated during five previous days, when no tea or coffee was taken, an ordinary diet being observed in each instance ; on the other hand, 15 grammes of green coffee caused a diminution of upwards of 14 per cent. Thus in five periods of five days each :—

	Urine per diem.	Urea per diem.	Pulse.
1. Without tea or coffee	1126 grammes	24·98 grammes	74
2. With tea	1145 „	23·64 „	64
3. Without tea or coffee	1046 „	25·00 „	68
4. With coffee	1259 „	21·80 „	62
5. Without tea or coffee	1242 „	26·18 „	69

The circulation is also affected by the tea or coffee, the pulse being perceptibly slower when these bodies are taken than when not consumed. *Comptes Rendus*, lxxvii. 489.

Sugar Beet.—SESTINI and DEL TORRE have examined the influence of various kinds of manures on crops of sugar beet. The best results were obtained with superphosphate, which yielded the following results as compared with those obtained without the use of any manure at all on the same soil :—

Varieties of Beetroot examined.

1. Vilmorin.
2. Magdeburg.
3. Silesian.
4. Imperial.
5. Disette d'Allemagne.

Average weight of Roots.

	Manured.	Unmanured.
1.	706·33 grammes.	439·00 grammes.
2.	601·33 „	416·00 „
3.	749·00 „	411·00 „
4.	1339·000 „	415·00 „
5.	848·00 „	307·66 „

Yield of Sugar per 100 parts of Juice.

	Manured.	Unmanured.
1.	11·075 parts.	10·995 parts.
2.	11·695 „	11·181 „
3.	8·023 „	10·912 „
4.	11·401 „	8·703 „
5.	11·381 „	13·026 „

Wood ashes containing potash are also a good manure for sugar beets; transplanting does not give good results with the first four varieties, but answered better with the fifth. Castor oil cake, according to Montanaro, increases the sugar in the juice one per cent.

Thick sowing appears to be advantageous, inasmuch as a larger yield of sugar is obtained from a given weight of roots when they are comparatively small than when they are larger.

The following table exhibits the weights of sugar obtained from equal sized plots differently manured :—

Not manured at all . . .	2,143	kilogrammes.
Manured with ashes . . .	2,567	„
„ „ stable manure .	2,939	„
„ „ superphosphate .	2,950	„
„ „ stable manure thickly sown .	3,529	„

Gazzetta Chimica Italiana, iii. 190.

Improvements in the Determination of Juice in Beetroot.—F. JICINSKY finds that the determinations of the amount of sugar in beetroot by polarization of weighed and measured samples never differ more than about 0·1 per cent., and he thinks it therefore indifferent which of the two methods be used. Several precautions are given with regard to the extraction of the juice. If cold water be employed, four extractions of the pulp are required; if water at 60° to 80° be taken, two digestions suffice. The maceration of the material should never be performed on the filter, but always in the beaker, from which the juice is poured into the funnel; this latter should have at its bottom a platinum cone, in order that such portions of the pulp as have gone with the liquid into the filter may be kept back.

The following table exhibits the results of comparative examinations by extracting the same kind of beetroot with cold and hot water, twice and four times :—

Cold digestion.		Hot digestion.		Remarks.
Twice.	Four times.	Twice.	Four times.	
11·00	11·00	11·80	11·75	Fresh root.
11·77	11·00	11·00	11·00	Fresh root.
10·50	10·70	10·70	10·65	
8·00	8·00	8·00	8·00	Altered winter-root.
8·40	8·40	8·50	8·50	

The author finds that Stammer's method invariably gives a higher percentage (3 to 8 per cent.) than his own.

When determining the amount of extract by the dry process, care should be taken not to raise the temperature above 100°, and, when the residue appears nearly dry, to lower the temperature to 90°; the author found that at 105° decomposition of the juice begins to take place.

There are three ways of evaporating the juice :—

(1) By adding to the juice a weighed amount of sand and then evaporating.

(2) By evaporating to almost dryness, moistening repeatedly with alcohol, and subsequently evaporating to complete dryness.

(3) By simply evaporating in a platinum dish.

The comparative value of the three methods may be gathered from the figures below :—

	By (1) method.	By (2) method.	By (3) method.
1 . .	89·38	89·08	89·28
2 . .	88·50	87·82	88·44
3 . .	87·26	87·10	87·16
4 . .	87·60	87·22	87·09

Zeitschr. für Zucker-Ind. in Böhmen: Dingler's Polyt. Journ. ccviii. 452.

Mechanical Force of Food.—A. SAUSEN calculates from the average work done by omnibus horses in Paris, that 1 gramme of proteine taken as food represents 1,600 gramme-meters of work. From the percentage of proteine in the food, and the weight of food eaten, the work done by the animal can be calculated; thus if n kilogrammes of oats containing 12 per cent. of proteine be given daily, the work done per diem is $n \times 120 \times 1{,}600$ gramme-meters. *Comptes Rendus*, lxxvi. 1490.

Wine Making by Chaptal's Process.—MOSCHINI and SESTINI state that by this process (addition of 83 parts of pure chalk for every 100 parts of free acid) the free acid nearly disappears, but the wine acquires a disagreeable taste and becomes turbid by exposure to air; the ash too is largely increased. On the other hand, if 43 per cent. only of pure Carrara marble powder be added, the acidity is corrected without injury to the flavour of the wine. *Gazzetta Chimica Italiana, iii.* 195.

Potatoes.—C. D. HUNTER has examined the effects of various manures on the crops of potatoes grown on light soil in Cumberland; both the size of the tubers and the amount of crop were increased by manures containing potash, but the repeated use of the same land for potatoes diminishes the yield in spite of manuring, although potash manures diminish this falling off. Thus the following results were obtained :—

Manure No. 1 Superphosphate.
„ 2 Superphosphate and chloride of potassium.
„ 3 Superphosphate and sulphate of ammonia.
„ 4 Superphosphate, chloride of potassium, and sulphate of ammonia.
„ 5 Superphosphate, chloride of potassium, sulphate of ammonia, and sulphate of magnesia.

Results in 1868.

Manure No. 1	7·15 tons per acre.
„ 2	7·43 „
No manure	5·92 „

Results in 1869.

Manure No. 1	5·07 tons per acre.
„ 2	6·68 „
„ 3	5·39 „
„ 4	9·10 „
„ 5	8·20 „
No manure	4·71 „

Results in 1870.

Manure No. 1	4·04 tons per acre.
„ 2	6·75 „
„ 3	4·52 „
„ 4	8·16 „
„ 5	7·45 „
No manure	3·21 „

With a soil in high condition manuring is productive of no advantage, and heavy dressings of soluble salts are prejudicial. Chloride of sodium does not produce the same results as chloride of potassium.

The author recommends the following mixture per acre :—

Superphosphate	6½ cwts.
Commercial "muriate of potash"	2½ „
Sulphate of ammonia . . .	2½ „

Although potash salts have the power of making the potatoes grown with them keep better, yet they do not in any way prevent disease. *Transactions of the Highland Agricultural Society*, 1873, 168.

T. FERGUSON has also examined the subject with analogous results. Potassium sulphate he found to be preferable to the chloride; whilst still larger crops can be got by means of manures containing phosphates and nitrogen without fixed alkalies. *Ibid.* 1873, 102.

Gases from the Nisiros Volcano.—GORCEIX gives the following analysis of the gases collected in March, 1873, from the fumeroles in the crater :—

	1.	2.
Sulphuretted hydrogen . .	65·0	8·6
Carbonic acid	30·0	90·2
Oxygen	0·4	—
Other gases (incombustible) .	4·6	1·2
	100·0	100·0

	3.		4.	
Sulphuretted hydrogen .	74·0	77·0	74·0	70·0
Carbonic acid . . .	21·6	18·0	21·6	25·3
Oxygen	0·4	0·4	0·4	0·4
Other gases (combustible) .	4·0	4·6	3·7	3·8
	100·0	100·0	100·0	100·0

Sample 1 was from an old fumerole, 3 and 4 from newer ones, the second analyses being derived from portions collected three days later. 2 is from a solfaterra in the Isle of Cos. Sulphur was deposited near the fumerole, the soil being impregnated with sulphuric acid. *Comptes Rendus, lxxvii.* 597.

Gases from the Springs at Inselbad (Padeborn).—E. v. MEYER finds that the gases from one spring (unenclosed) contain :—

Carbonic acid . . .	1·61	1·48
Oxygen	7·33	7·38
Nitrogen	91·06	91·14
	100·00	100·00

Another spring is built over for patients to respire the gases. The air in this room differs little from atmospheric air. Possibly the medicinal action may be due to excessive humidity, or the presence of salts mechanically suspended. *J. Prakt. Chem.* [2] *vii.* 181.

Manures.—A. H. CHURCH has examined the manurial value of various waste products.

Fresh blood contains :—

1 per cent. phosphoric acid.
5 „ potash.
3 „ ammonia (as nitrogenous matter).

Dry blood contains five times as much. To make a blood manure, dry peat may be used as an absorbent, or better, 3 per cent. of quicklime may be added to coagulate, and the whole then dried.

Flesh, hair, wool, fish, &c., may be disintegrated by heating under pressure with steam. The resulting mass can readily be powdered after drying. Horn may be gently roasted and then powdered.

Glue refuse is a slimy substance, containing 1·75 per cent. of nitrogen when moist, 3·8 when dry ; whilst *trotter scutch* (tannery refuse, consisting of skin, hair, &c.) contains from 3·58 to 7·60 per cent. of ammonia (as nitrogenous matter.)

Fresh hops contain 1·91 per cent., when dry 4·20 per cent. of ammonia (as nitrogenous matter), and the deposits from fermenting liquors are rich in nitrogen. Sugar-boilers' scum contains nitrogen and also phosphates, beetroot sugar scum containing from 4 to 6 per cent. of ammonia (as nitrogenous matter).

Spent galls contain :—

Potash	0·90 per cent.
Phosphoric acid	0·17 „
Ammonia (as nitrogenous matter) .	1·32 „

The liquors obtained in rotting flax and hemp contain nitrogen equal to 2·7 to 4·0 per cent. on the dry residue.

Wheat embryos separated by Child's decorticating process, and great puff-balls (*Lycoperdon giganteum*) weighing from 1 to 2 lbs. each, gave the following results on analysis :—

	Wheat embryos.	Great puff-ball. Fresh.	Dry.
Water . .	12·53	90·87	—
Albumenoids .	35·70	5·48	66·78
Oil . . .	4·18	0·90	11·00
Cellulose, &c. .	41·83	2·10	14·78
Ash . . .	5·76	0·63	7·44
	100·00	100·00	100·00

In the analysis the nitrogen is wholly calculated as albumin ; part, however, in the case of the puff-ball, existed as nitrates. The ash consisted of :—

Phosphorus pentoxide . . .	46·19
Potassium oxide	35·48
Sodium oxide	6·95
Lime	2·47
Ferric oxide	1·08
Silica	0·66
Undetermined	7·17
	100·00

Transactions of the Highland Agricultural Society, 1873, 220.

Essence of Unona Odoratissima.—GAL states that this essence is distilled from the flowers of a tree growing in Jamaica, and comes into the market under the name of *Alangilan* (Ihlang-Ihlang ?). It has the specific gravity 0·98, and is lævorotatory ; it distils between 160° and 300°, and appears to be a mixture of benzoic ethers, as benzoic acid is obtainable from it by saponification with potash. *Comptes Rendus, lxxvi.* 1482.

The Unwholesomeness of Cast-iron Stoves.—MORIN, PAYEN, DEVILLE, BERNARD, BUSSEY, and RÉMY, have been commissioned by the French Academy to investigate this subject. Experiments were instituted with stoves of cast and wrought-iron, using soft coals, with the view of learning under what conditions stoves of metal become unhealthy through the presence of carbonic acid and carbonic oxide in the rooms heated by them. The result of two experiments, one with dry air, the other with moist, are given in the report. Rabbits were made to breathe the air passing over stoves of cast and wrought-iron heated to redness, and afterwards chemical examination of the blood of the animals was made, to ascertain the presence of carbonic oxide. The following words are used in giving the results of the experiments :—"If the summary of the experiments made upon rabbits does not permit us to fix with any precision the proportions of carbonic oxide absorbed by their blood, nor that of the oxygen which has been expelled from it, the results all agree to show that the use of stoves of cast-iron heated to a red heat causes in the blood, by the presence of carbonic oxide, a gas eminently poisonous, changes whose repetition may become dangerous ; while the same method of investigation has not revealed analogous effects when the heat has been produced from stoves of wrought or sheet-iron." In experiments made prior to the above, Morin came to the conclusion that with surfaces of wrought-iron heated to a red heat carbonic oxide is produced, his experiments showing that the passage of the air over cast and wrought-iron heated to redness causes the development of carbonic oxide to an extent noticeably greater in the case of cast-iron than in that of wrought. In presenting the conclusions or results of the entire series of experiments made upon stoves of cast and wrought-iron during the year, the commission reports as follows :—"The carbonic oxide, whose presence has been proved when stoves of cast-iron are used, may arise from several different causes : 1st. The permeability of the stove by that gas, which will pass from the interior of the fire-pot to the exterior. 2nd. The direct action of the oxygen of the air upon the carbon of the cast-iron heated to redness. 3rd. The decomposition of carbonic acid contained in the air by its contact with metal heated to redness. 4th. The influence of the organic dust naturally contained in the air." Another very important conclusion is arrived at by the commission, viz. that all stoves and heating apparatus of cast-iron, and even those of wrought-iron, should be lined with fire-brick, or other substance, so as to prevent them from attaining a red heat.

In America, where stoves are generally used, and more anthracite than soft coal is burnt, the subject has long attracted attention ; but from the recent rise in the price of fuel in England, and the probable large introduction of stoves for the sake of economy, a reference to it here may not be without its use. No more prominent cause of disease in families exists than such devices for burning anthracite coals in cast-iron stoves not provided with good fire-brick linings.

Mercury in the System.—HYATT recently exhibited the leg bone of a man whose death had undoubtedly been hastened by mercury. On striking the bone, out fell thousands of little glittering globules of metallic mercury, which rolled about, collecting here and there into drops. This mercury had been absorbed during life, undermining the man's system, and ultimately proving fatal to him. The mortality among those who work in mines of quicksilver, or in the works where it is reduced, is known to be frightful. In the celebrated mines of Idra, the men work alternately one month in the mines and one month in the smelting-house. But notwithstanding this, it appears that of the hundreds employed there, one-fourth become salivated. In the Royal College of Surgeons there is another leg-bone which is riddled by mercury.

Lead-Poisoning.—BELGRAND states that ordinary water even when the calcareous salts do not amount to more than a centigramme per litre, does not dissolve lead, and that rain-water has no action on that metal, probably because of the presence therein of certain salts of lime. *Revue Scientifique, November*, 1873. *p.* 479.

[This statement is in direct opposition to experience and the observations and experimental results of numerous chemists.]

VERNOIS, on the other hand, cites a case of saturnine poisoning of a family through drinking water which had remained a long time—probably three years—in the service-pipes of a house. *Loc. Cit.*

Hay Fever.—DECAISNE thinks that emanations from forage plants play but a very secondary part in this disorder, patients being attacked by it just the same if not exposed to these influences. It occurs at any season, and no proof is forthcoming of its periodical reappearance at some special time of year. He considers it as a catarrhal fever, influenced and modified in its cause and progress by individual idiosyncrasy and certain atmospheric conditions, which produce bronchial affections. *Comptes Rendus*, 1873, *August* 25.

Toothache.—H. REYNOLD employs acetate of lead to cure toothache: about 15 centigrammes (2 grains) of the solid substance are placed in the cavity of the tooth; in a few minutes the pain wholly disappears.

Rubbing the gums with oil of jusquiame often relieves violent toothache. *Moniteur Quesneville*, 1873, 844.

Poisonous action of Cobalt.—SIEGEN finds that nitrate and chloride of cobalt are poisonous, acting directly on the muscles of the heart: 1 centigramme of either preparation killed a frog in half an hour; 30 centigrammes killed a strong rabbit in three hours. *Les Mondes, xxxii. No.* 5.

Influence of Sulphates in Goitre.—BERGERET concludes from his observations on 250 goîtrous soldiers at St. Etienne, that in this case a quantity of sulphate is present in the urine to the extent of three or four times the normal quantity. This, however, is not derived from the water drunk, which is so pure that photographers use it in place of distilled water; the author considers that the cause of the complaint is excessive work without a suitably proportioned diet, whereby an excessive oxidation of sulphurized animal constituents is produced, tending to goître. *Comptes Rendus*, 1873, *Sept.* 29.

BARON LARREY thinks the so-called epidemic of St. Etienne may be solely due to mechanical causes, such as the pressure of a button, collar, clasp, &c., on the thyroid gland; he terms the complaint *thyreoïditis*, and not goître. *Ibid.*

Brittleness of the Bones of Cattle.—J. NESSLER has examined the bones of several cattle affected by a disease peculiar to a certain district of the Black Forest, which causes the bones to become brittle. The following selected analyses show the general character of the results obtained:—

	Bones of Pelvis.		Tibia.	
	Sound.	Diseased.	Sound.	Diseased.
Ash . .	45·49	36·75	61·02	66·95
Phosphoric acid	15·93	12·81	25·92	25·74
Lime . .	——	18·54	32·81	——
Fat . .	25·52	36·65	1·90	1·57
Nitrogen .	3·77	4·00	4·62	4·72

A deficiency in inorganic constituents is noticeable in spongy, porous bones, but not in the long bones, such as the tibia or os femoris, or bones of forearm; less phosphoric acid, however, is present in all cases save the forearm; and a deficiency in weight is also marked in many cases as compared with the weight of healthy bones from animals of the same size and age. Probably the causes of the disease are deficiency of lime and phosphoric acid in the food. The disease usually attacks cows in calf and young cattle, and is only noticeable in farms which overlie granite or sandstone; other farms resting on gneiss in the neighbourhood of those affected are usually free from the disease, save in very dry seasons. Change of pasturage frequently cures the afflicted beast. *Landw.-Versuchs-Stationen. xvi.* 187.

§ 5. *Fuel, Gas, Illumination, Photography, &c.*

Virginian Coal.—The coal measures of Western Virginia have been opened up by the Chesapeake and Ohio Railroad. The Great Kanawha River, formed by the junction of the New and Gauly rivers in Fayette County, flows north-west to the Ohio for 90 miles, falling into that river at Point Pleasant, 201 miles below Pittsburgh, and 210 miles above Cincinnati, cutting through the richest portion of the Great Alleghany coal-fields. Recent surveys confirm previous reports as to the enormous deposits of coal in this favoured region. The coals of this district are singularly accessible, and are, moreover, of exceedingly good quality. Unusual facilities attend mining operations, as the large number of workable seams directly available above the water-level renders the sinking of shafts unnecessary. Navigable streams exist in close propinquity to a large number of the largest seams, and the certainty that no expense can be incurred by the irruption of water into the mines, lends an additional attraction to enterprise. Three kinds of coal are found in the Kanawha Valley—bituminous, splint, and cannel. The bituminous coal is equal to the best found in Pennsylvania, that raised by the Winifrede Company showing the high percentage of 68·53 of fixed carbon.

Splint coal is found in seams ranging as high as 12 ft. in thickness. It burns well, has high calorific power and intensity, is tolerably free from sulphur and other impurities, and leaves but little ash—not more than 1·81 to 62·61 per cent. of fixed carbon, and is, therefore, admirably adapted in its raw state for use in the blast-furnace. Now that the Bessemer process is rapidly superseding all others, the existence of coal specially suited for making the quality of pig-iron necessary for "conversion" assumes great importance. The firmness and solidity which render the splint coal of Kanawha capable of being shifted and stored with very little loss will be thoroughly appreciated when it is stated that where it has been thrown out on the mountain side, from old openings, many years ago, it may be found in many cases covered with moss, while on the shoals of the creeks and rivers are scattered lumps varying from the size of a pebble up to 20 and 30 lbs. weight, smooth and water-worn. How long they have been there no man can tell; but when broken they are found as black, rich, and solid as when first torn from the parent seam. Cannel coal lies very near the surface, and in many places lies absolutely exposed. It is generally found accompanied by bituminous, or by splint coal, or by both. The cannel in the seam at Cannelton, on the Kanawha, has extremes in the workings of 10 in. and 5 ft., with a general average of from 39 to 42 in. As gas coal, cannel has no superior, and that found in Western Virginia occupies the highest position of any known, save only that from Boghead. Scottish cannel (Boghead) is unrivalled in quality, but unfortunately its quantity is limited, as its range does not extend more than three or four miles, and the seam varies in thickness from 1 to 30 in. The gas-producing power of this coal is extraordinary. It contains only 9·25 of fixed carbon to 69·0 of volatile matter, while next to it comes the coal of Cannelton, with 41·30 of fixed carbon and 46·50 of volatile matter. Fifty-six gallons of oil have been produced from a ton of Kanawha cannel, but the increased output of mineral oil from the Pennsylvania wells reduces this industry to comparative insignificance. The cost of digging this coal was last winter about $3\frac{1}{2}$ cents per bushel. The Kanawha Valley is full of iron ore, but the quality of the latter is hardly rich enough to induce the erection of blast-furnaces on its own account. The real wealth of iron lies not upon the Kanawha but further south, upon New River and in Southern Virginia, where brown hematite exists in massive beds of great extent, and ranges through a vast extent of country. Railway communication being open between this district and the Kanawha Valley, the production of hematite pig and Bessemer steel will probably be stimulated to an enormous extent. *Iron, Nov.* 1873.

Composition and Technical Properties of Coals.—CARL HILT believes that the ratio between the volatile matters of coal and the coke thence obtained may be made the basis for classifying coals with regard to technical requirements. Thus—

	Ratio of volatile matter to coke.
Anthracite	from 5 to 10 per cent.
Flint coal	„ $10\frac{1}{2}$ „ $15\frac{1}{2}$ „
Caking	„ $15\frac{1}{2}$ „ $33\frac{1}{3}$ „
Caking gas coal	„ $33\frac{1}{3}$ „ 40 „
Gas coal	„ 40 „ $44\frac{2}{3}$ „
Ditto	„ $44\frac{2}{3}$ „ 48 „

The first kind of coal requires a good draught, gives very little flame, no soot, and is specially adapted for household requirements, for heating of kilns, and occasionally for boilers.

The flint coal serves for the same purposes as anthracite, especially as a boiler fuel.

The caking coal is the coal *par excellence* for all industrial purposes, labouring under the sole disadvantage that it gives off a little soot.

The caking gas coal gives the best gas and the largest amount of it, but its yield of coke is poor.

The last named two kinds are those most serviceable for reverberatory furnaces. They are also largely used as fuel under boilers, but they give off large masses of dense smoke. *Dingler's Polyt. Journ. ccviii.* 424.

Expelling Sulphur from Coke.—HOFMANN states that the sulphur of coke can be removed in the form of sulphuretted hydrogen by pouring over glowing coke an acid solution of manganese chloride. In a large puddling establishment on the Rhine, a liquor consisting of solutions of the chlorides of manganese and calcium has been successfully employed for this purpose. *Dingler's Polyt. Journ. ccviii.* 463.

Pyrometers.—WEINHOLD gives a number of readings from various pyrometers compared with the air thermometer, from which it appears that errors of ± 50° are by no means uncommon even in fairly constructed instruments, viz. Gauntlett's, Bock's, and Oechste's.

As the air thermometer is practically inapplicable in industrial operations, the Siemens specific heat pyrometer, or one

acting on the same principles, is most convenient when a tolerable degree of accuracy is required.

When wrought-iron is employed, the following table indicates the relation between the rise in temperature from zero and the heat communicated to a kilogramme of metal :—

Quantity of Heat.	Rise of Temperature.
0·53	0° to 5° C.
1·06	„ 10
1·60	„ 15
2·13	„ 20
2·67	„ 25
5·38	„ 50
10·94	„ 100
16·70	„ 150
22·67	„ 200
28·87	„ 250
35·31	„ 300
42·02	„ 350
49·01	„ 400
56·30	„ 450
63·90	„ 500
80·10	„ 600
97·15	„ 700
116·90	„ 800
137·95	„ 900
160·76	„ 1000

A Siemens pyrometer showed, when compared with the air-thermometer, differences, especially from about 600° upwards, *but these differences were tolerably constant*, so that they may easily be corrected, once the deviation of an individual instrument has been ascertained. *Dingler's Polyt. Journal, ccviii.* 124.

[Our own experience entirely corroborates the above statements: it is not difficult to construct a table of errors for a Siemens pyrometer by making a few observations at exactly known temperatures (boiling point of mercury, sulphur, &c.), and comparing the indications of the instrument with the true temperatures employed: intermediate temperatures are then readily obtained by interpolation. The errors of graduation, &c., in these instruments, as found in commerce, are frequently very appreciable, so that every instrument should be checked as to its correctness before it is used for any accurate work. The same remark applies to most mercurial thermometers, though to a much less extent.—*Chem. Ed. P.M.*]

Influence of Iron Slag on Fire-clay at High Temperatures.—C. BISCHOF finds that Hessian, Mülheim, Grünstadt, and Belgian fire-clays are fused at a temperature at which platinum loses its ductility. The tests were made by forming small cylinders of the clay mixed with a certain amount of slag, and exposing them to a temperature at which platinum begins to fuse. In this way it was ascertained that the normal Hessian fire-clay altered when mixed with 1 per cent. of slag; Grünstadt, Mülheim, and Belgian clays demand at least 5·7 per cent., and some other specimens as much as 13 and 14 per cent. It was further found that the presence of siliceous sand increased the infusibility of certain specimens of clay.

A trial made with different kinds of slags, containing respectively 54 and 41 per cent. of lime, showed that the former had a greater tendency to render fire-clay fusible.

New Fire Engine.—THOMAS ATKINS has invented a new engine, the principle of which consists in saturating the water thrown on the flame with a gaseous mixture consisting of 18¼ parts of carbonic acid, 1½ carbonic oxide, and 80 of nitrogen manufactured from charcoal, and which possesses the important advantage of only effervescing slowly although introduced at a high pressure. Its cheapness is another advantage, the cost not exceeding 1*s.* for 1,700 square feet. The working standard is 150 lbs. to the inch, but it can be stored at 1,000. An experiment was fairly successful, and quite sufficient to give the inventor a claim to the attention of the public. A pile of fagoted brushwood and shavings, well saturated with tar, and about twelve feet in length, was set fire to, and it speedily burst into a furious blaze. It was then attacked with the new engine, and in a few minutes the flames were completely extinguished with the expenditure of about 17 gallons of fluid, a good deal of which was evidently superfluous. One of the great merits of this invention is stated to be the prevention of the asphyxiating qualities of the smoke, which may be breathed without inconvenience.

Prevention of Fires on Board Ship.—M. SCHUPPERT proposes to place in the holds of vessels whose cargoes are liable to spontaneous combustion, boxes filled with marble dust, into which pipes convey dilute sulphuric acid. The carbonic acid gas disengaged by the contact of the sulphuric acid will extinguish the fire; the gas, being heavier than atmospheric air, can easily be confined to the hold of the vessel.

Incrustation of Boilers, &c.—The inconvenience and positive danger occasioned by incrustation are more evident than the success of the remedies as yet proposed. One of the latest examples of these, as regards water-pipes, occurs in Boston, where the fire insurance companies are now calling attention to the condition of the water-pipes of that city. It seems that the water supply is greatly diminished by the incrustation formed on the inside of the iron pipes by the action of the water, so that a 3-inch pipe that has been laid ten years becomes reduced to 2 inches, those of 4 inches to 3, and the 6-inch mains reduced to 5 and 4 inches. A pipe was recently taken up through which one could not see, though water flowed slowly; and a pipe of 3-inch bore was taken up filled up solid with deposit. In the suburbs cement pipes are used, but it is said they are hardly strong enough to bear the needful pressure. *New York Times.*

The "Silber" Light.—The light-giving material is oil, which is converted into gas before it enters into combustion. This arrangement, which forms the leading feature of the new light, lessens the consumption of the wick, does away with the gathering of impurities in it, and by effecting complete combustion, obviates the smell arising from imperfect combustion. The flame is white, regular, and uniform. The illuminating power of a burner of 1¼ in. width is equal to that of twenty-eight sperm candles, each consuming 120 grains per hour; the light of a 1¾ in. burner equals that of fifty such candles.

The speciality of the construction is a row of two perpendicular double cylinders, concentrically arranged at a certain distance from one another. The two inner cylinders contain the wick; the outer pair, which is in connection with the wick as well as the reservoir, conducts the oil from the latter to the former; the hollow space between the inner cylinder of the interior pair carries air to the inner side of the flame, and the hollow space between the two couples of cylinders conveys air to the outer side of the wick. The mouth of this system of cylindrical cells is closed by a dome-shaped piece of metal, provided with an opening from which the gas issues and comes into contact with the air.

The nature of the oil leads to slight modifications in the construction. The present lamps are arranged for rape-oil and light liquid hydrocarbons. *Dingler's Polyt. Journ., ccix.* 79.

Reduction of Silver Salts applied to the reproduction of Designs.—RENAULT takes advantage of the circumstance that whilst paper impregnated with oxygen salts of silver can be easily reduced by hydrogen, copper, or phosphorus vapour, this is not the case with the haloid salts of silver.

The drawing to be copied is placed on a sheet of cardboard which has previously been treated with vapour of muriatic acid, and upon the drawing is laid a sheet of paper brushed over with a solution of the double nitrate of silver and iron. The hydrochloric acid vapour penetrates the drawing-paper wherever it is free from lines, and reaching the sensitized paper in the unprotected places, converts the oxygen salt into chloride of silver, leaving the other portions unchanged. After this treatment the sensitized paper is laid on a copper plate, or treated with hydrogen, or in some other way exposed to reducing influences. The silver chloride part remains unaltered, whilst the other portions of the paper blacken, and thus present a good copy of the original design. The fixing of the reproduced drawing may be carried out by any of the usual methods. *Dingler's Polyt. Journ., ccvii.* 62.

Colour Photography.—L. VIDAL modifies the carbon process so as to get chromatic photographs as follows. Several negatives are taken, and the parts not required to be of any one given colour stopped out with black varnish, &c. From each of these negatives as many portions are printed as are required (the desired monochrome being employed instead of carbon) on parchment-paper which has been previously soaked in alcoholic shellac solution; then positives are printed and fixed, and these covered with a thin film of gelatine and dried; two are then pressed together under water, so as to adhere, and are then allowed to dry; alcohol then removes the shellac and parchment-paper. In the same way any number of partial prints in different colours are transferred to the final support just as in ordinary lithographic printing; the provisional support being tolerably transparent, there is no difficulty in making the different coloured prints tally with one another. *Comptes Rendus, lxxvii.* 340.

§ 6. *Electricity and Magnetism.*

Gramme's Electro-magnetic Machine in its application to Galvanoplastics and Illumination.—The inventor instituted a series of experiments with a specially constructed test-apparatus, and compared the results with those obtained by an electro-magnet in which the power of the magnet is known.

The machine for galvanoplastics had been for some time past in use. It consisted of an axle carrying two movable and two fixed horizontal electro-magnets. It weighed 460 kilos, and would precipitate with a velocity of 300 revolutions per minute 600 grammes of silver. The weight of the wires wound upon the fixed magnets was 135 kilos, and that of movable magnets 40 kilos. The force required to work it amounted to 1-horse-power. The tension of the current equalled that of two ordinary Bunsen elements, and the quantity corresponded to 32 elements.

The following table shows some of the results obtained by Gramme's and Wilde's machines :—

GRAMME'S MACHINE.

	Total precipitate in grammes.	Time of precipitation.	Surface of positive pole in square metres.	Precipitate per hour in grammes.	Precipitate per hour and per square metre, in grammes.	Observations.
		h. m.				
1.	5973	7 50	5·3550	766	143	300 revolutions per minute.
2.	5905	7 50	,,	757	141	Bad precipitate.
3.	5972	7 50	,,	766	143	Porous precipitate.
4.	6117	7 50	,,	784	146	
5.	1980	2 50	3·3570	707	198	300 revolutions per minute.
6.	1985	2 45	,,	722	202	Good precipitate.
7.	2014	2 45	,,	732	205	
8.	1557	2 35	2·6775	603	225	300 revolutions per minute.
9.	1593	2 45	,,	581	217	Bad precipitate.
10.	1540	2 40	,,	578	216	Grain precipitate.

WILDE'S MACHINE.

	Total precipitate in grammes.	Time of precipitation.	Surface of positive pole in square metres.	Precipitate per hour in grammes.	Precipitate per hour and per square metre, in grammes.	Observations.
		H. M.				
1.	1481	3 30	2·6775	423	158	2400 revolutions per minute.
2.	1144	2 30	,,	457	170	
3.	1481	3 5	,,	480	179	
4.	1689	3 35	,,	472	176	

By increasing the velocity to 325 revolutions, the quantity of precipitate obtained amounted to 675 grammes, but on such occasions the coils were heated to an extent which would have damaged the machine if continued.

The advantages of the lesser velocity of the Gramme machine are obvious. It is only necessary further to state that, after having worked for several months, the machine was in as good order as at starting, and that its working required not a centime of expense, if the lubricating of the axle-bearings is excepted.

Though the machine is not arranged for the precipitation of copper, nevertheless some experiments for this purpose were made by Christofle with the following results :—

	Precipitate per hour, in grammes.	Surface of the positive pole (lead) in square metres.	Precipitate per hour and per square metre, in grammes.
1 . .	142	0·90	158
2 . .	142	,,	158
3 . .	133	,,	148
4 . .	125	,,	139
5 . .	128	,,	142
6 . .	161	1·30	123
7 . .	149	,,	112

The machine intended for the production of light is, of course, constructed on a somewhat different principle ; the tension, in this case, is considerably higher and the quantity less than for the purposes of chemical decomposition. Thus, the tension in one of Gramme's machines amounts to that of 105 Bunsen elements, whilst the quantity is reduced to that of 5 elements. The apparatus is vertically arranged ; its height is 1·25 metres, its base 0·8 square metre, and it weighs about one ton. It has three movable and three fixed magnets with 250 kilos of wire on the first set, and 75 kilos on the second. Rotating with a velocity of 300 revolutions per minute, for which a force of 4 horse-power was needed, a light equal in intensity to 900 carcel burners was obtained ; *i.e.* the most powerful of all artificial lights hitherto produced.

With a velocity of 300 revolutions, it was possible to raise to red heat a copper wire of 0·7 millim. diameter and 12 metre length, and an iron wire of 1·3 millim. diameter and 5 metre length. The latter wire melted throughout a length of 2·5 metre. *Dingler's Polyt. Journ. cxvii.* 31.

Electromagnetism.—MAYER has announced some instructive conclusions from a series of experiments upon magnetism. These experiments were made with a view to investigate the change of dimension suffered by bars of steel or iron by magnetization. Faraday was the first to discover this temporary elongation of an iron bar when magnetized by passing an electric current around the same, while Henry verified these experiments, some ten years ago, by means of an apparatus of extreme delicacy. The apparatus employed by M. Mayer is also very delicate, and capable of measuring a variation in length of one two-hundred-thousandths of an inch. The bars of iron which suffered an elongation when they were magnetized by passing a current of electricity around them, shortened somewhat when the current was interrupted, but never quite regained their original length. With annealed steel bars the results were the same ; but with tempered steel they were quite different. Upon passing a current around these they contracted, and on interrupting the current they contracted still farther.

§ 7. *Miscellaneous.*

Consumption of Paper.—ALBINUS RUDAL makes the following calculations :—

A Russian consumes 1lb. of paper per annum ; a Spaniard, 1½ lb. ; a Mexican or Central American, 2 lbs. ; in Italy and Austria the consumption is 3½ lbs. per head ; in English America, 5½ lbs. ; France, 7½ lbs. ; Germany, 8 lbs. ; United States, 8¾ lbs. ; England, 11½ lbs. Hence the intellectual activity of a nation may be gauged by the paper consumed per head. A portion, however, of the paper used is employed for manufacturing purposes, and this varies with each nation.

The author estimates that the paper made throughout the world from all sources (linen, flax, calico, cotton, jute, Esparto grass, &c., &c.) amounts to 1,800,000,000 lbs., or 800,000 tons. Half of this is used for printing, one-sixth for writing, the rest for other purposes. The various governments consume 200,000,000 lbs. ; education, 180,000,000 lbs. ; commerce, 240,000,000 lbs. ; manufacturing industry, 180,000,000 lbs. ; private correspondence, 100,000,000 lbs. ; printing, 900,000,000 lbs.

To produce this paper, 3,960 factories exist, employing 90,000 men, and 180,000 women ; 100,000 rag pickers also are employed. In the United States, the total fabrication being 374,000,000 lbs., the imports are only 3,000,000 lbs. *Revue Scientifique, Nov.* 15, 1873, *p.* 480.

[The civilization of a country may, it has been calculated, be also estimated by the *soap* consumed annually per head. This basis of computation is less to the advantage of continental nations than that used above, viz., paper.—*Chem. Ed. P. M.*]

Why the Chemical Industry of the Continent is ahead of that of England.—LUNGE thus speaks of the rapid progress which the Continent is making in the manufacture of the finer chemicals. "You find in every chemical works on the Continent, I may say, without exception, one, sometimes several, chemists of thoroughly scientific training, who have acquired their theoretical basis by three or four years' studying at a university or a polytechnical institution. One 'works,' to which I have already alluded, certainly one of the largest in Germany, keeps something like half-a-dozen such chemists (not practical managers), with salaries varying from £300 to £400, and it retains the services of an accomplished chemist, of scientific reputation, at a salary of nearly £2,000 per annum, exclusively for theoretical work in the laboratory, without any trouble or responsibility connected with the manufacturing work outside. But then, they *do* constantly invent new things there,

and make them in tons, or hundreds of tons, when the chemical world outside has, perhaps, barely heard of the discovery of a new compound, with a barbarous name, apparently only obtainable at the rate of a few grains in a sealed tube after many weeks' patient work. What I maintain, after a visit to the Vienna Exhibition, and to several German and Austrian chemical works, is, that foreign countries are taking the wind out of our sails very fast in this line, and that both their rate of progress and the means of attaining it are very much superior to ours." *Inaugural address, Newcastle-on-Tyne Chemical Society.*

[*Note by Abstractor.*—It has been stated that 8,000 tons of anthracene are annually exported from England to Germany, from whence they return in the shape of alizarin and other allied colouring matters. R. G.]

Ventilation.—L. PINZGER has made calculations as to the quantities of air necessary for proper ventilation. These are based on the assumption (1) that a grown-up individual exhales per minute 0·005 cubic metre air, containing 4 per cent. carbonic acid; (2) that this carbonic acid penetrates uniformly into every part of the space, and (3) that the pure air introduced into the space mixes in a moment with the interior impure air to a homogeneous mass. For different localities and different circumstances the following figures were obtained:—

CUBIC METRES OF AIR REQUIRED FOR 1 PERSON IN 1 HOUR.

	Ventilation in Summer, and also with cold air in Winter.	Ventilation, when heated with hot air.
1. In Hospitals:		
(*a*) for ordinary sick	60—70	80—90
(*b*) for wounded and lying-in women	100	120
(*c*) in epidemic cases	150	180—200
2. In Prisons	40	50—55
3. In Workshops:		
(*a*) of usual kind	60	80
(*b*) with polluted air	100	120
4. In Barracks:		
(*a*) by day	30	40
(*b*) by night	40	50
5. In Theatres	40	50
6. In halls, when used for long periods	60	80
7. " " short "	30	40
8. In Schoolrooms	20—25	25—30

It may also be remarked that the effect of a middle-sized gas light is equal to that of nine persons. *Dingler's Polyt. Journ. ccvii.* 82.

Metallic Hailstones.—EVERSMAN has had occasion to examine at Kasan, hailstones containing crystallized iron pyrites. The cause of this rare phenomenon, no doubt, was that small crystals of pyrites proceeding from the disintegration of a rock had been transported by a tempest into the clouds, where they were iced and converted into hailstones.

Dull Varnish.—A. HUGHES states that in order to prepare a varnish which does not reflect light it is only necessary to mix a solution of resin with some liquid in which resin is insoluble. By mixing 2½ parts of benzol with a solution of 3 to 5 parts of sandarac in 48 parts of ether a varnish is obtained which resembles ground glass when dry. Dammar resin with benzol as solvent, and the solution mixed with ether, yields also a good dull varnish.

The following mixture gives good results:—

Ether	560 parts by weight.
Benzol	240 "
Sandarac	40 "
Canada balsam	10 "

Dingler's Polyt. Journ., ccviii. 465.

Vessels for protecting Chemicals against Atmospheric Moisture.—KOENIG employs for this purpose pots provided at the top with a hollow rim into which the cover fits. This rim is filled with castor-oil before the cover is let into it. By this arrangement the atmospheric air is completely excluded. Bleaching powder has thus been kept for more than two years without undergoing any change. *Polyt. Centralblatt*, 1873, 66.

Adulterating Peppermint Oil with Castor Oil and Alcohol.—Peppermint oil, when evaporated on a piece of paper, ought not to leave any stain; if it does so, it proves the presence of some fatty oil. If a sample is thus ascertained to contain foreign substances, it is submitted to distillation, when the peppermint oil will pass over, whilst the fatty oil will remain behind. By mixing water with the sample, before rectifying it, any alcohol it might contain will also be left behind. The admixtures amount often to above 50 per cent., but the general appearance of the oil, its taste, its smell are the same as that of unadulterated peppermint oil; its sp. gr. however, is in such circumstances lower than that of a pure sample. *Dingler's Polyt. Journ. ccviii.* 464.

Parchment Solution.—GOUWAGRON prepares this solution by putting gutta-percha into ether, in which it becomes soft and semi-fluid. When spread on a sheet, over a picture, &c., the ether evaporates and leaves the gutta-percha as an extremely thin, but very durable membrane. Coatings of this kind are easily cleansed from dirt, &c., by means of a wet cloth. Charcoal and chalk drawings, which are apt to be easily effaced, are fixed by spreading over their surfaces a fine spray of this solution. *Dingler's Polyt. Journ. ccviii.* 235.

Utilization of the Residues obtained in Chaudet's process for removing the Fat from Wool.—The fatty waters are treated in stone tanks with the sulphurous acid from pyrites furnaces. When the liquid shows a distinct acid reaction it is allowed to stand for twenty-four hours. It will after this time be found to have separated into three layers; the upper one consisting almost entirely of impure fat; the next below it being a solution of alkaline sulphites, and the lowest containing the earthy impurities. The solution forming the middle stratum is evaporated to dryness, and the residue ignited, whereby the sulphites are converted into sulphates, which can be purified by crystallization. The top layer is pressed in bags to obtain the fatty acids. *Dingler's Polyt. Journ. ccviii.* 465.

A MEAT-PRODUCING COUNTRY.

THE grazing regions of North America comprise both slopes of the Rocky Mountains, and embrace more than one-half the total area of the United States. This immense pasture land extends from the Mexican boundary on the south to the British possessions on the north, and from the 21st parallel of latitude west from Washington to the Pacific Ocean, and embracing an area of 1,000,000,000 acres. In prehistoric ages this country was the favourite herding ground of the buffalo, and their bones lie bleaching in all directions, while their paths, deeply worn, cover the plains like a network. Elk, antelope, and deer still feed here, and the mountain sheep are yet to be seen upon the mountain sides, and in the more secluded valleys of the Sierra Madra range. The soil of the country is produced by the disintegration of the limestone, sandstone, and granite ridges of the mountain range, and is therefore dry, gravelly, and porous, except on the borders of the streams, where the soil is a dark mould, formed from the decomposition of the vegetation growing on the mountains; and the grasses of the wide plains and valleys, and on the lower mountain sides are the bunch, buffalo, grama, mesquite, and in some valleys the blue-joint, red-top, and wild rye grass. These grasses grow and flourish up to the timber and snow-line—to an altitude of 10,000 ft. The climate of this region is much like that of Asia. The rainfall is light, being about eight inches annually in the country west of the Missouri River, and east of the Sierra Nevada Mountains, while the snowfall at the altitude of 7,500 ft. is only 2 ft. The fall of snow at any one time is small, and it never lies on the ground so as to afford sleighing or cover the grasses. The rainy season is in May and June, and after these months the only rain that falls is from electric showers. Vegetation grows luxuriantly during the months of May and June, but when the rain ceases, the grasses gradually dry on the ground, so that by the time the frosts come in September they have become perfectly cured, uncut hay. Several scientific authorities could be cited to show that the climate is uniformly dry, and that the rain and snowfall are small, as in the interior of the other continents, where there has been winter grazing throughout the whole historic period. From the date when the first military posts were established west of the Missouri River, in 1834, up to the present, the animals employed in freighting supplies to those posts have been wintered on these great plains, and in the mountain valleys, with no food but the cured and uncut grasses, and no shelter but that afforded by the bluffs and hillsides. When the emigration commenced to California in 1849, the thousands

of horses and mules employed were wintered in the valleys of the Rocky Mountain regions without hay or grain; and in 1857, when General Johnson moved an army of several thousand men, with the usual number of citizens, *employés*, and followers to Utah, all the animals used in carrying supplies for this army were wintered in the valleys by grazing alone. The thousands of animals that have been since employed in the building of the Union Pacific Railroad, in carrying the freighting to New Mexico, Colorado, Utah, Montana, and Idaho, were all wintered upon the uncut grasses. From this it must be evident that winter grazing is safe and profitable in all this vast rocky mountain region, where perennial pastures, "boundless, endless, gateless," open wide their broad domains for the raising of cheap beef and mutton to feed the millions. The country west of the Missouri river is one vast pasture, affording unequalled summer and winter grazing, where sheep, horses, and cattle can be raised with only the cost of herding. The testimony of some of the largest stock-owners in these regions, who had from 15,000 to 20,000 head of cattle, might be adduced to show that cattle have been not only kept in good order on this grass during the winter, but many of them, thin in the fall, have become fine beef in the spring. Upon these unoccupied plains and mountain slopes all the flocks and herds in the world could find ample pasturage, and the day cannot be far distant when a country in which the grass grows and ripens untouched from year to year, and where the climate is so mild that tens of thousands of cattle can be wintered in herds without any artificial shelter, must become the mother of the largest flocks and herds in the world. The question whether the products of this immense grass farm are within the reach of the English consumer is one of the deepest interest not only to stock-dealers, but also to the people of Great Britain. *New York Times.*

The American Engineer and Inventor:

SELECT ABSTRACTS OF PATENTS RECENTLY GRANTED IN THE UNITED STATES.

[*For information concerning this department see the notice on the wrapper below the Contents of the Number.*]

441. Improved Pruning Instrument.

A pole of any desired length is made hollow to receive a wire, which passes through it longitudinally. Upon the upper end of the wire is cut a thread to screw into the shank of the saw which projects above the end of the pole, and fits into a dovetailed groove or socket in the side of a ferrule attached to the upper part of the pole, where it is secured by a set screw. By this construction, in using the instrument, the hook is passed over the twig to be cut, and the wire pulled down through the pole. The saw is operated by the reciprocating movement of the wire and pole upon each other.

442. Improved Self-Closing Faucet Attachment.

An inside collar, at the end of the faucet tube, serves as shoulder rest for a spiral spring, which coils around a tubular valve, resting with its other end against a shoulder of the same. Apertures at the end of the valve allow the liquid to pass out through the tube when that end projects outside. A solid extension of valve, of smaller diameter than the same, is threaded, and holds, by nut, a soft rubber disc and a strainer on the end of the tube. The rubber disc is of the same diameter as the tube end, the strainer fitting closely over the same. By the joint action of the spiral spring and cut, the disc is pressed firmly against the end of the tube, closing the same effectively, so that no liquid can escape. The faucet, when it is desired to draw off the fluid, is turned in far enough to strike the valve, forcing the same back, so that the disc is carried toward the inside of the vessel, and the apertures of the valve pass to the outside of the tube. The liquid enters, therefore, through the strainer and apertures into the valve and the faucet, and is easily allowed to escape.

443. Improved Bee Hive.

This invention consists in an improved bee hive formed of a number of cells, provided with a roof, and supported by a single shaft or post from a base. Around the foot of the post is placed a vessel to receive water to prevent ants and other insects from crawling up. The main frames are formed of an upper and a lower plate within the cells, connected at their side edges by two or more bars. In the top and bottom plates of the main frames, and midway between the side bars of said main frames, are formed grooves to receive the top and bottom bars of the single frames, so that the said frames attached to them may be drawn out conveniently and without breaking or otherwise injuring the comb, or the comb in the main frames. The bottom plates of the main frames are slotted to give free passage ways to the bees. The lower or open ends of the cells are closed with plates, which are secured in place by buttons pivoted to the partition walls. The buttons are semi-circular in form, which enables them to be turned to release one plate without releasing the other.

444. Improved Feather Renovator.

The outer casing forms, together with the semi-circular bottom of sheet metal or other suitable material, a steaming chamber, the upper part of which is of hexagonal shape and arranged with hinged lids, and perforated screens below them. A hollow shaft passes centrally in longitudinal direction through the chamber, and carries, near the side walls of the same, drums, with perforations of the sides facing toward the interior. Longitudinal strips connect the drums, and act as stirrers on their rotation. The steam is admitted to the hollow shaft from its opposite end, and passes through the perforated drums to the interior of the chamber, being led out again by means of tubes at the top of the casing. The doors are tightly closed during the steaming process, to produce a thorough cleansing of the feathers. The condensed water, together with the dirt, collects at the bottom of the chamber, and is drawn off through a dumping box. The drying chamber extends from the lowest point of the steam chamber along its full length on the side opposite the dumping box. It is provided with the entrance and exit pipes through which the steam is admitted and let out for drying the feathers after the steaming process is completed. The outer doors or lids are opened during the drying and cooling process to allow the free passage of a current of cold air through the feathers.

445. Improved Manufacture of Steel.

This invention relates to a compound prepared from soft iron, tungsten, and nickel, which forms a cast steel of superior quality. The proportions used are: for the first quality, soft iron, ninety-three parts: tungsten, six and one half parts; nickel, one half part. For the second quality, soft iron, ninety-five parts; tungsten, four and one half parts; nickel, one half part. For the third quality, soft-iron, ninety-seven parts; tungsten, two and one half parts; nickel, one half part. The furnaces and crucibles employed are the same as those ordinarily used in the manufacture of cast steel. The tungsten and nickel are mixed together and inclosed with a suitable flux in a soft sheet iron tube, which is placed in the centre of the charge, said charge being sprinkled over with a quantity of the flux, varying (in proportion to the quantity of the metal treated) between one half part and two parts of flux to one hundred parts of metal. As soon as the mass has become liquid it is run off in the usual way into a sand or metal mould, the latter being lined with a mixture of clay and percarburet of iron. Before and during the process of running off the fused metal, a vacuum is produced in the mould by covering the bottom of the funnel with a diaphragm of parchment, which is destroyed by the contact of the fused metal. When the alloy is run into a metal mould, the ingot is removed as soon as it becomes solidified. It is then annealed in a closed vessel, and allowed to cool gradually. The steel produced as above described may be hammered in the same way as ordinary steel. The flux is composed of biborate of soda, calcined silex and carbonate of lime, pulverized in a mortar, mixed together, placed in small quantities in a crucible heated to a white heat, and, when liquefied, run off on a fluted cast-iron plate. Finally, the flux thus obtained is crushed into small particles before it is used.

446. Improved Vessel for Transporting Grain in Bulk.

Cross stays are placed about half way between the deck and the bottom of the vessel, and are connected for the support of the sides. Stanchions are placed on each of the cross stays, supported at right angles with the deck, and have partitioned boards on each side, which divide the portion of the hold above the cross stays into three compartments. The partition boards on the insides of the stanchions extend from the deck about one third the distance to the stays. Those attached to the outer sides of the stanchions extend from the cross stays upward a short distance above the low edges of the inner partition boards, so that the two boards of each set of stanchions lap past each other. The compartments are connected by the spaces between the stanchions, so that the grain may pass over the outside partitions from the outside compartments, and under the inside partitions into the central compartment. This is done as the vessel rolls and is careened. The result is, the central compartment is soon filled after the vessel commences to roll, and the grain in that compartment is retained. By this improvement, shifting of cargo, it is claimed, is so prevented that no damage can occur, and the vessel is navigated as easily as it is when laden with immovable cargo.

447. Improved Folding Camp Baker.

The object of this invention is to provide (for the use of surveying parties, expeditions, and others, who are obliged to encamp in the field at some distance from human habitations) an improved baker, which can be readily folded up after use. The invention consists of a main part with two side wings and a top hinged to it, which are arranged and connected by suitable rods for carrying the baking pan. The latter is placed in a horizontal position by elevating the main part by means of hinged supports. The main and hinged parts may be folded up so as to incase the pan and lock all the parts safely together.

448. Improved Propulsion of Vessels.

This invention consists in an improved wave motor for turning the propeller screw of a ship, vessel, or boat. A heavy platform is suspended by pivoted rods, so as to vibrate freely with the pitching of the ship. The after rods are extended each some distance upward, and to their upward ends are pivoted bars, which are also pivoted to vibratory rods which carry reversed spring pawls. These pawls move alternately ratchet wheels, which are rigidly attached to independent sleeves that are loose on a shaft, and have each a large bevel spur wheel. Between these wheels, and engaging with both, is a small bevel pinion on the propeller shaft, which, by the motion of the two large wheels, is turned by either alternately in the same direction. The vibrations of the platform are thus utilized and transferred to the propeller. Patents on this invention have also been obtained in England and various countries on the continent.

449. Improved Inclinometer or Grading Level.

This invention has for its object to furnish a simple and inexpensive but efficient instrument for readily determining grades, inclinations, or angles of various surfaces; and it consists in applying a graduated extensible bar to the ordinary carpenter's or mason's level, and providing such means for adjustment and clamping the same as will enable it to support the level at various inclinations, and indicate the grade.

450. Improved Bee Hive.

This invention consists in making the honey frame of a bee hive in separate sections, so as to turn like the leaves of a book, thus facilitating inspection, and in making the case in sections locked detachably by suitable projections and recesses to enable too large a swarm of bees to be easily divided.

451. Improved Gauge Cock.

This invention consists in a cock valve and seat, the former arranged to rotate about the stem in combination with a spiral spring that yields sufficiently to allow readily the rotation of the valve, and yet to hold it in any position desired.

452. Improved Car Coupling.

The coupling pins are passed through the bumper head, and are made with shoulders upon their upper ends, which rest upon the upper sides of the bumper heads, and are secured in place by pins passed through them at the lower side of the said bumper head. Upon the upper ends of the pins are formed hooks, which point toward the car bodies. The coupling link couples the ears by being dropped over the hooks of the pins. A short standard is connected with the middle part of the coupling link, and receives an arm which is pivoted to said standard by a pin passing through a longitudinal slot in the said arm, to give the link the necessary play to accommodate itself to the various movements of the bumpers. The other or inner end of the arm is attached to a short shaft, which is pivoted, and to which is attached a short arm, to the outer end of which is pivoted the lower end of the rod which passes up through a keeper attached to the car body. To the rod is attached a double stop to hold it in place. By this construction, by raising the rod the link will be raised from the hook pins, uncoupling the cars; and when the rod is lowered, the link will be lowered upon the hook pins, coupling the cars.

453. Improved Combined Padlock.

This invention relates to permutation locks, and consists in novel means by which the combination of numbers may be conveniently changed. The peculiarity of this permutation lock consists in pivoting a plate on a stud that has projections which act in conjunction with notches on a subjacent plate, and thus allow the changes of combination to be easily effected.

454. Improved Broom Hanger.

There is a metallic spring loop and an open spring band, the two being connected by eyes. This band is made large enough to receive the small end of a handle, so as to hold it by friction. The loop is hung upon a nail, and thus suspends the broom.

455. Improved Windmill.

This invention consists of novel contrivances for causing a pumping windmill to start and stop self-actingly by the influence of the water raised up into the tanks and

by weights; it also consists of an ingenious contrivance for adjusting the vanes to take the wind more or less, by the influence of the wind; and it also consists of an extension of the frame to the front side of the wheel, to furnish a bearing for the front end of the shaft.

456. Improved Wheel for Vehicles and Mode of Detaching Horses.

The tire is semi-circular in form, or has its edges bent inward, so as to enter grooves in the felly. A nut is inserted in an open cavity in the felly, and a sheet metal cap is then applied over the felly at that point, and its flange covers the lateral opening of said cavity. A screw having a head passes through nut and cap. The end of the spoke tenon rests or abuts on the screw head. The sheet metal socket is divided longitudinally to adapt it to be fitted over the screw head, and is tightly clamped around the nut and around the spoke tenon by rings. When it is desired to disconnect the felly and spokes, the bands are slid off the socket, and the latter may then be sprung off the head of the screw. Another improvement in wheels by the same inventor consists in a metal plate, let into the felly in the axis of the spoke, and secured by a pin. The bearing piece for the end of the spoke is clamped on the felly by a key. The cap has flanges overlapping the sides of the felly to secure it against splitting. The bearing piece may be cast together with the cap. The spoke is slotted at the end suitably to be fitted on the plate and key, and it is firmly secured thereon by a plate bent around the spoke and secured by bands, which are driven on tight and secured by solder. An elastic washer is placed between the band and cap to lessen the shocks. The same inventor has also patented an improved device for detaching horses from shafts. Near each end of the whiffletree is attached a short arm, in the outer side of which is formed a recess to receive a projection formed upon the inner side of a similar arm, which is pivoted to the end of the whiffletree. With the pivoted arm is connected a spring, so as to draw back the arm whenever it may be released. To the outer side of the short arm is attached a loop to receive the tug and prevent it from sticking upon the projection of the other arm and being carried with said arm when it is drawn back. To two levers is connected an eye by means of which the levers are operated to withdraw catches and allow the pivoted arms to spring back, releasing the tug. The eye may be operated by hand, or by a wire extending to the carriage, and secured in such a position that it may be readily reached by a person in said carriage to detach the horse when desired.

457. Improved Middlings Separator.

This invention has for its object to furnish an improved apparatus for separating middlings into grades, so as to enable a larger per cent. of first grade flour to be made from the wheat by mixing with the first grade or grades of the middlings. The unsorted middlings pass through a spout against a disc which distributes them centrifugally upon inclined aprons, whence they pass down, the heavier portions to an incline and the lighter into a cylinder. The latter are drawn by a suction fan through one pipe, and discharged through another into a chamber. Here the air blast is regulated to cause a deposit of a second grade, while the lighter passes on to another chamber. This operation is continued until as many grades are obtained as may be desired.

458. Improved Corn Planter Runner Bending Machine.

This invention relates to means whereby the runners of corn planters may be cheaply, conveniently and effectually bent into the desired shape; and consists in a vibratory segment provided with slotted arms, between which are placed side rolls and a reciprocating top roll combined with a curved former and a superposed bar, the subjacent surface of the latter gradually approaching the top of the former from front to rear.

459. Improved Tanning Compound.

This invention relates to a method of neutralizing the acid which remains in hides after they have been tanned, and which are calculated greatly to damage the leather. It consists in removing the acid from previously tanned hides by immersing them in a bath or solution of salt and soda, according to a formula fully set forth in the specification of the patent.

460. Improved Hoe.

This invention is an improvement in that class of hoes which are double-bladed, that is, pointed on one side or edge and straight on the other or opposite one, to adapt them for different kinds of work. The invention consists in bending or striking up the hoe blade, so as to form a central rib on the inner side or surface thereof, and a corresponding groove on the other side, the same extending from the centre to the termination of the pointed end. The object of this construction is twofold: to strengthen the hoe blade and adapt it to work easily in the earth, and to form a suitable recess to receive the end of the handle socket or other devices by which the blade is secured to the handle. The remaining feature of the invention relates to the construction of the handle socket, whereby it is adapted for firm and durable connection with the hoe blade and for other purposes.

461. Improved Blowpipe.

This invention relates to a peculiar construction of that class of blowpipes which are used in connection with a lamp, whose flame is expected both to vaporize the liquid in vessel and to be forced upon and melt metals or solder. The invention consists in a blowpipe of two connected chambers, having front convexities with intermediate air space, the ejection being located upon the upper convexity while the lower receives the flame that is to generate the vapour.

462. Improved Thrashing Machine.

The grain is fed to an endless apron by which it is carried beneath the beaters, which are attached to a shaft, and which are bent at a little distance therefrom, so that as the said shaft rocks, the said beaters may strike squarely upon the endless apron and platform beneath. The extreme ends of the beaters are bent upward to prevent them from catching upon the endless apron.

463. Improved Harness Trace Buckle.

The object of this invention is to produce a trace buckle, which forms a strong and more effective connection of the straps the greater the strain applied to them, being perfectly free from friction by cutting or breaking a trace off. The frame of the buckle is provided with an inclined loop at one end, and a loop at the other end, toward the hames. At the turning point is an indentation. A central lateral connecting piece carries the upright tongue of about the height of the end loops, which admit the heaviest and thickest traces in use. The trace is suitably perforated to fit over the tongue. Another loop consists of two parts, of which one connects with the hame strap, and has a side expansion to embrace the curved loop of the frame. A lateral bar divides the double loop centrally, and bears against the indentation, producing thereby a twofold connection of frame with the loop. A strain exerted on the trace and hame strap causes an upward gliding of the bar, and thereby a tightening of the hold on the trace.

464. Improved Harvester Rake.

A tubular standard supports a bevelled wheel which turns loosely thereon and carries a horizontal rim turned by the driving wheel. The rake arms are pivoted on the upper side of this rim, and arranged so that the inner ends work upon a stationary cam as they are carried along, which allows the arms to rise at the inner ends and fall at the outer ends to bring the rakes down to the apron. Suitable degrees are provided in order that this cam may allow some of the rakes to pass above the grain on the apron of the machine when the grain is so light that a quantity sufficient for a gavel does not accumulate as each succeding arm passes. For intercepting some of the rakes, there is a tappet wheel with, say, three rows of tappets on its face, and capable of sliding lengthwise to bring either set of its tappets into action according as demanded by the volume of grain, the said sets each being arranged for having a different effect in throwing out the rakes—that is, varying the order of throwing them out. It is shifted by suitable mechanism arranged in a place where it can be reached conveniently by the operator to shift it at will, and provided with a holder by which it can be held in either of three positions corresponding to three sets of tappets.

465. Improved Saw Set.

In the groove of a bench is arranged a setting plate over which is a setting clamp and setting tool. The clamp consists of a strong bar extending over the setting plate nearly its whole length, then binding horizontally beyond the edge, and then down through the frame to levers which are forced down by a screw to press the clamp down on the saw, which is laid on the plate. The levers are forced up by a spring. The tool is forced down on the saw teeth by the blows of a hammer, and it is forced up by another spring.

466. Improved Cotton Gin.

The brushes consist of two flanges, in halves, and bolted together around the shaft, with brushes attached to the sides and projecting obliquely forward, or in the direction in which they turn, and meeting together at the middle of the space between the flanges. There are, also, bristles attached to the shaft, between the flanges, and projecting radially from it. The object of having the bristles project forward is to have them impinge with greater force against the sides of the saws than they otherwise would, and prevent them from being sprung backward away from it. A wide, endless carrier of canvas is arranged under the saws to receive the seeds and other droppings, and carry them out through the gin case. There is an endless chain carrier in the hopper, with teeth to convey the cotton along from the place of receiving it to the passage through the top of the gin case. This works in connection with an open wire bottom above the chains, an open wood bottom below them, or either alone, and a gauge to spread and equalize the cotton, regulate the quantity supplied to the gin, open the bolls, and remove them and other coarse matters, which are arrested by the teeth of the gauge or regulator, and caused to fall, through the open bottoms, to the gin case, from which they are carried, by teeth, into the drawer, which is removed from time to time and emptied.

467. Improved Machine for Making Chains.

This invention has for its object to furnish a machine which shall be so constructed as to bend the iron into link form, weld its ends, and make a complete chain by a continuous operation. In using the machine, the parts being in position, a bar is laid upon the notched upper ends of fingers. As the machine moves forward the former is thrown into place and the fingers move upward, bending the bar around the former. Lips descend upon each side of the upper ends of the bent bar, and a die comes down, bending the ends of the bar down upon the upper part of the former. The die rises slightly, and the lips are forced toward each other, welding the ends of the bar between the lips, the former, and the die. The movement of the lips toward each other allows the lock or catch bar to drop, confining the lips in position. The former is then withdrawn from the link, and the sleeve, the lips, and the link make a quarter revolution, coming into such a position that another bar may be thrust through the link and laid upon the ends of the fingers. A locking bar now slightly descends, bringing its bend in contact with a block, which releases the lips, allowing them to spring apart and the link to drop upon the bar. The lips now return to their former position, the former is thrust forward, and so on. The chain, as completed, passes down through a hollow bar.

468. Improved Wind Wheel.

To the upper part of the wheel shaft are rigidly attached four or more short wings, to the outer edges of which are hinged other wings, which are all connected and held in the same relative position by a rope secured to each, and which allows them to move freely upon their hinges. A weight is so arranged as to hold the other wings against the wind in ordinary circumstances, but, should the wind increase in force, it will turn them back upon their hinges into a position more or less oblique according to the force of the wind. As the wind decreases in force the weight draws the wings back into their former position. A hood, made in the form of a half-drum, is designed to cover about one half of the wheel and protect the returning wings from the action of the wind.

469. Improved Hydraulic Brake.

This invention consists in means whereby steam, water, and air may be conjointly applied to operate car brakes with great certainty, efficiency, and economy. Two steam cylinders and two water cylinders have an outlet tube, so connected with the rams that the introduction of steam in one cylinder results in the expulsion of water from the other. The steam valves and valves of the water outlet tube are connected by intermediate mechanism, and operated by one and the same lever. The piston-rod of the hydraulic engine is connected with brake bars. Provision is made for readily applying the brakes, in case of rupture or breakage of the connecting pipes.

470. Improved Apparatus for Cleansing Dyed Wool, etc.

This invention consists of a trough attached to a tank for holding the wool and the scouring and cleansing mixture, having one side curved from bottom to top, and provided on the inside with fixed blocks or wire netting. Above there is a curved track, on which a carriage having blades projecting down to the curved bottoms is arranged to run forward and backward to force the wool up the sides of the tank and over the blocks. The latter are inclined on the sides against which the wool is forced, and the arms of the truck are hinged so as to swing up and pass over any portion of the wool that may be under the points in going back, so as not to tear and injure the fibre.

471. Improved Mop Holder.

This invention consists of a lateral head-piece attached to a mop-stick, between which and a wire clamp the mop is tightly held. The wire clamp is provided with coiled springs, which swing sidewise on pivots of the head-piece, with upward extending parts hooked to the sides of the handle.

472. Improved Wheel for Vehicles.

The spoke is provided with a round, shouldered tenon, which enters a hole in the felly. The thimble fitting on said tenon is reduced and screw-threaded for one half its length, and on such reduced portion a nut is screwed, and also a jam nut. The thimble is applied to the spoke tenon with its larger end abutting against the shoulder thereof, and has ribs which take into notches on the spoke, for the purpose of preventing the thimble from turning. When the tire requires to be tightened, or the felly adjusted, a wrench is applied to the larger nut, and it is turned or screwed back toward the felly until the distance between the spoke shoulder and the felly has been sufficiently increased to produce the desired effect.

473. Improved Pitman Rod.

This invention consists in improving the pitman rod connection for which letters patent were granted to the same inventor, Nov. 19, 1872. The forward end of a screw, to which is attached a milled nut, rests against a block which is inserted in the inner end of the inner brass. The body of the screw passes through a washer, and its other end is inserted in the rod. This end of the screw is flat, to prevent the screw from turning when the nut is screwed down against the rod. Bolts, which pass through slotted holes in the straps, fit tight in the rod and brass, and are moved with the latter as they are pushed outward; but the hole through the long strap for one bolt, and the hole for the other in the short strap, are so arranged that, when the screw and nut push out the rod, block, and brass, the straps are drawn in just as much as the screw and nut push the rod and blocks apart, so that all the wear and lost motion is taken up without changing the length of the rod. The two cross-bars described in the former patent are taken out, and the two bolts mentioned substituted.

474. Improved Jig Saw.

In the front of the frame is a vertical dovetail groove, in which a corresponding tongue on the adjusting plate fits to control said plate in adjusting it up and down, and to hold it. For the latter purpose an eccentric cam is arranged, provided with a weighted arm, which, when it falls, causes the eccentric to bear the tongue against the walls of the groove with sufficient force to bind it fast. There is suitable mechanism in order to lift the weighted lever and unfasten the plate by the hand used for adjusting said plate, and at or just before the time of adjusting it. Thus only one hand is employed for these two purposes, and the other is free to do other things necessary to

be done at the same time. The upper cross-head carries a couple of griping jaws pivoted near their lower ends, and curved, outward and then backward, nearly together at their upper ends to provide room for a ball between them, to which a spring is connected. The upper end of the saw, having a slight head upset on it, is placed between the said jaws at the lower ends, and the spring is hitched to the ball, so as to pull it upward between the upper ends of the jaws, which forces the lower ends to gripe the saw and hold it with great force. The lower cross-head has two sliding jaws between two inclined plates, and a double spring connected with said jaws, and extending down to an eccentric lever. The saw, also having a small head upset on the lower end, is placed between their jaws at their upper ends, and they are forced up by the two levers between the inclined plates, and thereby forced hard against the saw. These modes of fastening the saw are very simple, and allow of changing the saws with but very little labour and loss of time.

475. Improved Life Preserver.

This invention consists in making a cape weatherproof, water-repellent and inflatable, so that, while it affords the usual protection for sailors and seafaring people, it is also a life-preserver.

476. Improved Bee Hive.

The feature of novelty in this hive is the arrangement of the honey frames on the comb frames proper, so that both may be supported by the same hinges, and removed from the hive together.

477. Improved Car Brake.

This invention relates to that class of brakes which are operated by steam from the locomotive. It consists in the mode of providing the cord with a take-up mechanism by means of a tube and pulley-frame, jointed so as to fold up when the trucks come close together, and to unfold as they separate, thereby maintaining a constant tautness in the cord which connects the power with the brake mechanism, and preventing the brakes from being applied unintentionally.

478. Arms of the Law.

It is doubtful whether any similar weapon of offence, unless it be the sand club or slung shot, is more liable to cause severe injury or even death by a single well-directed and heavy blow than the ordinary policeman's "locust." For the preservation of order and peace it is manifestly necessary to provide men with suitable weapons. A recent invention of Messrs. Simon Beery, of Ohio, and J. W. McDonald, of Texas, for which a patent has lately been granted, is an elastic baton, of gutta percha, india-rubber, or similar flexible material, which appears to be an improvement over the heavy wooden "billy."

479. Improved Wheel Cultivator.

The axles at the inner ends of the hubs of the wheels are bent forward at right angles, and after projecting a short distance are bent upward at right angles. The bow is made double, and the parts of its ends are horizontal, parallel with each other, and at such a distance apart as to receive the coupling between them. The ends of the double bow have holes formed through them to receive and work upon the upright parts of the axles. The middle parts of the bow are at such a distance apart as to receive the tongue between them and allow the said tongue and bow to work freely upon each other and upon the bolt that pivots them to each other. The intermediate parts of the double bow are close together, and are rigidly connected. To the rear end of the tongue is pivoted a cross bar, the ends of which are pivoted to arms, the lower and forward ends of which are rigidly attached to the upper ends of the upright parts of the axle. The invention consists in the parts above mentioned all pivoted together and moving freely upon each other, in combination with the bent sectional axles.

480. Improved Manufacture of Iron and Steel.

The object of this invention is to produce a thorough separation of the impure cinder from the metal, and in this manner purify the iron or steel. This method consists in drawing off and removing from the fire or furnace the impure cinder arising from the ore or pig iron as fast, or nearly as fast, as it is made, and supplying its place (by the use of a flux) with a pure cinder. If the impure cinder arising from the ore or pig iron should be thick, and not liquid enough to separate thoroughly from the metal (as is often the case with cinder arising from ores or pig iron containing silica), enough flux is added to it to make it liquid, so that it will separate from the metal, when it is drawn off, and its place supplied with a pure cinder by adding more flux, and in this manner the impurities are separated from the iron or steel. Lime, flint, spar, or lean hematite or specular ore, or any other substance that will produce a liquid cinder free from impurities are used as a flux, depending somewhat upon the character of the ore or pig-iron employed.

481. Improved Tag Fastener.

The improvement consists in the manner of attaching a hook to the card or label by means of a cross bar. The hook is made of flat sheet metal, and its upper part is in the form of the letter T reversed. The cross of the T is attached to the card. At the end of the vertical part is a double barb, which securely holds the hook in place when it is once attached.

482. Improved Churn.

This invention consists of a peculiar and simple arrangement of supports for the dashers and operating mechanism; the said supports are mounted on the churn top, so that the dasher and driving gear are all removed when the cover is taken off, to afford unobstructed access to the churn case.

483. Improved Edge-Protecting Welt for Boots and Shoes.

This invention is a welt for the protection of the shoe upper, formed of a long, narrow strip of leather or other material rabbeted on the upper side to receive the upper, and bent or moulded to conform to the shape or outline of the sole.

484. Improved Belt Clamp.

Each clamp consists of a lower base piece and a top piece, which are connected by suitable thumb screws. Both pieces are grooved at their inner sides, taking hold of the belt-like jaws to prevent its slipping. The top piece is rounded off at one side and straight at the other, so that it may be swung open on one screw, and be quickly attached to the belt. The hole for the other thumb screw in same piece is slotted for opening and closing the same on the belt. The ends of the under piece are provided with recesses, and at their outer edges at the off-side of the belt ends with lugs. Rods extend longitudinally in recesses and connect the clamps, having right and left hand screw threads, with nuts working thereon. A ratchet is placed centrally on the rods for turning the same. After the clamps are applied, the rods connect them, as the lugs serve to retain the nuts in fixed position. Each turn of the ratchet produces then the gradual approach of clamps, and, consequently, the tightening of the belt for lacing, &c.

485. Improved Refrigerator.

This invention relates to certain improvements upon the refrigerators patented by the same inventor December 21, 1872, and May 6, 1873, and consists mainly in providing, by a compact arrangement of the ice chamber, in combination with the cold water and air chambers, a larger space for the provision chambers, and a complete and uniform ventilation of the same.

486. Improved Copy Holder.

This invention consists of a couple of long thin bars, supported horizontally side by side in a stand of any suitable kind and material for holding written or printed papers to be copied between them, to expose the line directly above the edge of one of the bars which serves as a guide to the copyist, the paper being drawn up, as each line is copied, to expose the next.

487. Improved Refrigerator and Cooler.

This invention consists in an outer box provided with doors in front, and at each end of its top, and is lined with galvanized iron. In the middle part of the case is placed a box also made of galvanized iron, and which is so supported as to leave a space between it and the lining upon its top, bottom, back, and sides. The inner box is designed to receive things to be cooled or preserved. In the spaces at the ends of the outer box are placed vessels to receive liquids to be cooled, and which are made of such a shape and size as to leave spaces between them and the lining and the box for ice. Pipes lead into the vessels through the bottom of the case, and are designed to extend to the casks or other receptacles in which the beer or other liquid is kept, so that the said liquid may be forced into the said vessels by force pumps.

488. Improved Picket Fence.

This fence is composed of two kinds of posts. Those forming the greater number rest upon the ground. The others are arranged at intervals, and are longer than the posts first mentioned. The distinguishing features of the fence are the zigzag base and straight top. The posts (both long and short) are arranged in panels which brace alternately in each direction, but the tops of some of the posts are brought to a line of wire. The wires are bound together between the posts by links which are so applied that the wires are drawn tightly against the sides of the posts, thus binding all of them together, and rendering the fence strong and substantial. A fence is thus made of short timber of the most durable kind, one well calculated to resist the currents of water as well as wind.

489. Improved Cosmetic Bottle.

This invention consists of a cup on the top of the bottle or on the stopper, so arranged that some of the contents of the bottle will flow into it when the bottle is laid on one side, and be held conveniently to be taken up by a sponge, brush, or other article for use, and the remainder will flow back into the bottle again when it is placed upright. The object is to avoid the use of a separate cup and the waste attending it, as in the present mode of using cosmetics.

490. Improved Reel for Harvesters.

The journals of the reel revolve in bearings, which slide upon bars in which several holes are formed to receive pins or bolts, so that the bearings may be moved to adjust the reel forward and back. To the bars also are pivoted the upper ends of connecting rods, the lower ends of which are pivoted to the outer arms of bent levers, which are pivoted at their angles, and in a reversed position, with respect to each other, to a bar of the frame. To the inner arms of the bent levers are pivoted the ends of another connecting rod. By this arrangement the two bars will be made to move exactly together, so that the reel will always be raised and lowered squarely. The reel may also be raised and lowered by operating a suitable lever, and held securely in any position into which it may be adjusted.

491. Improved Bolt and Rod Cutter.

This invention consists of a main cutter or lever or bar, to which is attached an eccentric lever, which bears on the revolving wheel of a sliding cutter acting on the bolts or rods. The opening of the cutters is produced by the action of the eccentric lever on a curved lever having its fulcrum on the main cutter piece, and acting also on the sliding cutter.

492. Improved Car Coupling.

The bumber head is made in two parts, upper and lower, divided horizontally and in the direction of their length. The upper part near its inner end has a rounded projection which fits and is pivoted in a corresponding recess in the lower part. At the forward end of both parts are shoulders. Between these enters the coupling bar, the end of which has corresponding projections which engage with said shoulders. To the inclined inner surface of the lower part is attached a spring which is held down against said inclined surface by projections of the upper part, and which, when said upper part is raised in uncoupling the cars, raises the shoulder of the coupling bar. The upper part is raised to uncouple the cars by a cord attached to its forward end, and which leads up to the platform or top of the car, or to both places.

493. Improved Scaffold Pole Clamp.

For fastening the horizontal poles to the vertical poles of scaffolds, it is proposed to have a short lever pivoted at the middle in a yoke next to its bottom end, so that the lower end, which is curved to fit the side of a round pole, will embrace a horizontal pole and press it tight against the side of the vertical pole. The yoke embraces the vertical pole and is powerfully drawn against it by an eccentric lever pivoted in the bars at the open end on the side of the vertical pole opposite the lever. By this means the upper end of the lever is forced against the vertical pole above the yoke, so that points upon said extremity, as well as upon the face of the eccentric lever, will be driven into the pole and prevent the clamp from slipping down. The eccentric lever is fastened with a binding chain pressed around the pole and attached to it. The lever, which clamps the horizontal pole, is detachably connected to the yoke, so that the yoke and the eccentric lever may be used without the clamping lever for a splice clamp for clamping two poles together lengthwise, according to a method heretofore patented by same inventors.

494. Improved Piano Action.

This invention consists of a combined repeating and back check attachment to the French grand action, by which it is designed to render said action equal to the most perfect repeating action. The attachment consists of a notched arm on the hammer rod and an adjustable headed screw on the jack, so contrived that as the hammer drops from the string, it is caught by the head of the screw in the notch of the arm and held in check about a quarter of an inch from the string, to allow it to vibrate. The rebound is prevented by the heel of the arm below the notch bearing against the head of the rod. The arrangement of the jack, hammer, butt, notched arm, and adjusting rod is such that, after the hammer is caught this way, the key being allowed to rise slowly, the jack will again fall into its notch as soon as the key has risen an eighth of an inch, so that a repetition can be made at any rise of the key above that amount.

495. Improved Children's Carriage.

This invention relates to the construction of carriages for children, and consists in the mode of connecting the axle with the bolster, by means of which concussion and jolting are avoided.

496. Improved Pen and Pencil Case.

This invention has for its object to furnish an improved pencil case which shall be so constructed as to form a longer handle when the pencil is extended than when constructed in the ordinary manner, and a still longer handle when the pencil is drawn in and a pen extended. The invention consists of the slot of the inner sliding tube, made with an offset in the middle part of said tube, and with its rear part parallel to but not in line with its forward parts.

497. Improved Harness Mounting.

This invention consists in the improvement of terret rings which are covered with leather, the edges of the leather being sewed together on the inner side of the ring. A metallic band is then slipped into the ring to cover the sewing and receive the wear. In putting the coverings on the mountings, the edges of the leather are received into grooves or rabbets in the ring, which hold the edges in place when an inner ring is introduced. By this improvement these mountings, it is stated, are greatly improved in appearance, rendered more durable, and can be produced at less expense than by the old method of manufacture.

498. Improved Ferry Boat for Trains of Cars.

This invention consists of a truck on a railway car ferry boat, mounted on a series of screws on each side and arranged with vertical guide posts. The screws of each side are geared to a line shaft running the whole length of the truck. At one end, the two line shafts are geared together and connected with a power mechanism, so that the railway track can at any time be adjusted up or down to coincide with the shore tracks, so that the rising and falling of the tide will not interfere with the running of the cars on and off the boat.

499. Improved Lightning Rod.

The object of this invention is to improve lightning rods by rendering them more durable and easily made and more permanently joined together; and it consists in the joint, and in such a construction of the rod that the pieces slip together, and the joint and the ends lap past each other and form the joint. Two rivets pass through the joint at right angles to each other, thus securely binding the parts together, and making the joint the strongest part of the rod.

500. Improved Measuring Faucet.

This self-measuring faucet consists of two faucets combined and a measuring cup. When a hollow plug is turned so that two orifices correspond in position, in whole or in part, the liquid in the can will run down into and fill the cup. When the orifice is closed, the orifice in the plug is brought in communication with an air tube, which subjects the contents of the cup to atmospheric pressure, and allows a free discharge thereof. The plugs of the faucets are connected by means of a gear wheel on each. The receptacle is placed beneath the discharge tube and the plug turned, which, by virtue of the gear wheel, turns the inner plug and closes an aperture. The liquid in the cup (and no more) is consequently discharged. When that quantity is drawn off, the faucet is turned back and the cup immediately fills, and it is ready to be again discharged.

501. Improved Children's Carriage.

This invention consists of the body of a child's perambulator mounted on the frame with rockers, so that it can be used as a cradle as well as a perambulator when it may be required to do so. Hooks are attached to fasten the body, so that it will not rock when it is not desired.

502. Improved Evaporating Pan.

The invention consists in providing the evaporating pan or vessel with a channel or canal surrounding the same at the top, and leading at the ends into a filter, which is in communication with said pan or vessel near the bottom, the object of such arrangement being to receive the overflow caused by ebullition of the saccharine juice and filter or strain the same before it again enters the vessel.

503. Improved Street Sweeping Machine.

This invention is an improvement in street sweeping machines of the class in which a fan is employed to draw the dust away from the rotary brush and into a suitable receptacle. The improvement relates to the arrangement of a train of driving gears for communicating motion from one of the truck wheels to the brush, in combination with vertically adjustable supports for said brush, whereby the raising and lowering of the same does not in any way obstruct or interfere with the train. The invention also relates to the arrangement of a curved sheet metal hood directly over the front upper portion of the rotary brush, and having a pipe leading from the centre thereof to carry off the dust. The machine is designed for removing snow from street railways as well as dust, and the broom is extended each side beyond the truck wheels as much as it is desired to remove the snow from each side of the track.

504. Improved Car Starter.

The object of this invention is to provide means for moving railroad cars by hand and by one man power; and it consists in a lever having a head adapted to be pivoted directly or indirectly to the drawhead of a car at its middle, and provided at each end with an arm, having a gripe so that the lever may be vibrated horizontally to each clamp arm, acting alternately to hold the rail and give purchase to the operator.

505. Improved Oil Can.

The invention consists in using a can to hold oil, a heater pipe to keep it in a melted state, and a pump to discharge it from the can, all being combined to operate together. The pipe may connect at the upper end with the exhaust pipe of a steam engine, or with the hot feed water pipe of a hot air reservoir, so that it can be readily attached at any time to be heated. It may be coiled within or around outside of the can, or a jacket may surround the can wholly or in part, with pipe connections to conduct the heating medium into and out of it. This plan is preferable to the ordinary method of setting the can on a stove to heat the oil.

506. Improved Seed Planter and Fertilizer Distributor.

This invention relates to an arrangement of vertically adjustable shoes or supplementary seed distributing hoppers with stationary receiving hoppers, whereby the delivery of seed from the latter to the former may be conveniently and perfectly controlled or stopped altogether, as required.

507. Improved Flour Bolt.

The object of this invention is to improve the old reel bolt in such a manner that the flour is cooled in bolting, so as to be fit for immediate packing; that it bolts faster and cleaner, and requires less cloth, which lasts longer time, as no middlings or bran remains in the bolt, offering thereby less opportunity for injury and destruction by insects. The invention consists in arranging the flour bolt in upright position, with stationary cloth, and a fan with straight and curved partitions.

508. Improved Stove Pipe Thimble.

The object of the invention is to furnish an improved casing for conducting stove pipes through wooden partitions, which is easily fastened in position, protects the lathing fully against any danger by fire, and leaves no communicating holes between the rooms, being fully covered by the plastering. It consists in a double casing, which is attached suitably to the wooden partition, being provided with bent-up face pieces and side perforations, through which the circulation of the air around the inner casing is kept up.

509. Improved Automatic Gate.

The improvement consists in a pendent swinging gate, connected by means of cranks and rods with pivoted levers, which are arranged horizontally and parallel to the roadway, so that, when a vehicle wheel is run on to one of said levers, the gate will be thrown by the superior weight of the vehicle into a nearly vertical position, leaving the passage way unobstructed.

510. Improved Children's Carriage.

The object of the invention is to so improve the child's carriage in common use that the handle part may be detached and applied at pleasure either to the front or rear of the body. For storage during the winter months, space is saved by the disconnection of the handle, which is, in many cases, a great convenience. The invention consists in attaching, to the front and rear ends of the carriage, sockets for the handle ends, into which the latter lock by means of suitable spring catches.

511. Improved Check Rein.

This invention consists in a check reig attached to the head stall on each side of the horse's head. A pulley is fastened by a frame to this rein. One end of a strap is passed around the pulley coupled with the ordinary check rein, and extends back within reach of the driver. This rein gives the driver complete control of the horse, as, by the purchase which he obtains by means of the pulley, he can draw the check just as tight as he pleases, and stop him or check his speed if he is disposed to be unruly, or attempts to run away.

512. Improved Mode of Securing Wheel Hubs to Shafts.

For fastening pulleys, cog wheels, &c., on the shafts in a way to save the expense of boring the hubs, turning the shafts, and fitting the wheels to the shafts, it is proposed to cast the wheels with their holes a little larger than the shafts, and with three or more grooves in said holes, in which gibs or keys are fitted. On the latter the wheels are secured and trued to the shafts by set screws, screwing through the hubs and clamping the gibs on the shafts.

513. Improved Apparatus for Cleaning Cesspools, Sinks, &c.

The object of this invention is to improve the machines for emptying and cleaning sinks, privies, cesspools, sewers, marshy lands, &c., in a perfectly odourless manner, so that the work can be done in the day time without the least discomfort or annoyance to the occupants of the dwellings, and without the use of separate machines by which the vacuum in the tank is created. The invention consists of a tank of suitable capacity, which is provided with double-acting pneumatic pumps and all necessary appurtenances to insure the efficient working of all the parts. The tank is carried on a four-wheeled track of suitable strength, and the vacuum is created by the hind wheels working the air-pumps by eccentrics, said action to be discontinued by the application of a regulating gear, which frees the piston from its shaft, according to a gauge placed on a cupola connected with the tank, which assists, also, the perfect working of the machine.

514. Improved Toy Device for Making Soap Bubbles.

The object of this invention is to furnish, for the amusement of children, a toy instrument by which soap-bubbles may be easily and quickly produced, without the spilling of soap-water and other inconveniences. The invention consists, mainly, in the arrangement of a double tubular casing for soap and soap water, with an air-pipe and exit tube, in which latter the quantity required is regulated by a suitably constructed valve arrangement.

515. Improved Internal Spring Coupling and Brake.

This coupling system is based on the use of one or several blade springs suitably curved, inclosed within a hollow drum or pulley, and working by their own expansive force, which keeps them pressing more or less closely against the internal cylindrical face of the said drum or pulley. This expansive force, independent of any exterior action, causes a close adhesion of the said spring to the hollow pulley, which makes them, as it were, a single piece by preventing their sliding on one another, and this adhesion can only be destroyed by an impulsion from the exterior. It follows, therefore, that if one of the two mentioned pieces, either the spring or the pulley, is set ln motion, it naturally carries along the other one, so long as the resistances which the latter has to overcome are insufficient to produce the sliding of the said pieces on each other, or so long as the adhesion between the spring and drum is not destroyed, either completely or partially, by any exterior action. The self-acting brake is claimed to afford security for the handling of the heaviest loads. The ascending movement being caused by the effect of the adhesion of the spring to the pulley, then if this adhesive force was able to raise the load, it will, of course, be able to maintain it in suspension at any period of its ascent. The workman has no ratchet to lift up, no kind of operation to perform in which he could make a mistake; he has only to turn the crank round to cause the load to ascend, to weigh lightly on the same crank in a contrary direction, in order to cause the said load to descend; he may, at pleasure, regulate the descending speed and stop it at any moment by only letting go the handle, having no effort to make, no danger to run, since the crank does not revolve when the load moves down, so that he has nothing to preoccupy his mind. The almost instantaneous stoppage which takes place when suddenly letting loose the handle cannot have any hurtful effect on the chain, for the active impulse is employed only to cause the spring to slide till that impulse is annulled by the friction of the latter on the pulley.

516. Improved Oscillating Gland for Flowing Oil Wells.

This invention relates to an apparatus which is fastened to the top of the casing to prevent the escape of oil or gas during the process of drilling oil wells; and it consists in a ball-and-socket gland which permits the rope from which the iron tool is suspended to pass through the gland oil and gas-tight, and to move up and down in the act of drilling without permitting either oil or gas to escape, except through proper orifices. If oil escapes, it may be conveyed to an oil tank, and if gas escapes it may be conducted off to a distance, so as to avoid danger.

517. Improved Method of Propelling Boats.

To the bar or lever of the paddle are hinged two blades in such a way that when moving forward through the water the pressure of the water will close them. These are kept from closing against each other by one or more stops interposed between them and attached to the bar, so that as the paddle begins to make the stroke the pressure of the water may open or spread the blades so as to present the greatest possible surface. The upper ends of the bar are designed to be attached to the shafts, which are arranged so as to be operated independently of each other. The shafts are placed in line with each other, and a pintle may be attached to the end of one shaft to enter a socket in the end of the other shaft. Levers are attached to the inner parts of the shafts, extending above and below said shafts, and having handles attached to their upper ends and foot rests attached to their lower ends, so that the operator can apply hand and foot power.

518. Improved Fastening for Bedsteads.

The object of this invention is to produce a simple and reliable means for connecting converging rails, boards, or pieces of articles of furniture, so that such converging or joining pieces may be firmly held together, but so that they can be readily taken apart. The invention consists in the application to such converging pieces of wedge-shaped or oblique-edged blocks, of which one is attached to each piece in such position that the two blocks, when overlapping each other with their oblique faces, hold the pieces to which they are attached properly together.

519. Improved Shears.

This invention consists of a compound lever arrangement of one of the arms or handles of the shears, to increase the leverage. The handle or arm is in two sections, of which one is a part of the blade, terminating a little beyond the pivot by which the two blades are connected together, and is pivoted at said end to the other section a short distance above its lower end. The latter is connected by a link to the handle for a fulcrum. It extends from the pivot which connects the two sections along with the other handle to its end. A wider sweep and more power is thus given to the blades. The improvement is designed more particularly for the "snip" shears used by tinners and others for cutting sheet metal.

520. Improved Picture Frame.

This invention consists of a round or oval frame of wood, metal, or other material, covered with velvet or other cloth, and the cover secured at the edges by ornamental spun metal bands, in addition to being glued to the surface of the metal or wood portions.

521. Improved Mordant for Dyeing.

This invention relates to the mordant chemically known as acetate of alumina. Acetate of soda is calcined to an anhydrous or a monohydrous state, and then pulverized by means of a fine sieve. The finest powder is removed and mixed with a fresh charge of hydrous acetate to be calcined. The coarser powder of average fineness is separated by another sieve, and forms the part prepared for use. Sulphate of alumina is ground and then sifted in a similar manner. The two coarse grained powders thus obtained are then mixed with each other, preferably by sifting both at the same time through an open sieve, and the mixed powder is ready for packing. The sulphate of alumina may be used in the form of crystal alum, concentrated alum, aluminous cake, &c.

522. Improved Elastic Seat for Railway Rail Joints.

This invention is an improvement in cushioning the joints of railroad rails, and relates more particularly to a socket plate for the rubber cushion, which is provided with end flanges to adapt the cushion for use with wooden sleepers or cross ties.

523. Improved Ice Cream Freezer.

In the bucket is made a stationary tube of perforated sheet metal. This is placed at the centre, and extends nearly as high as the top of the pail, and is large enough to receive the cream can, which has a non-conducting cover lined with charcoal. The ice is packed in the space between the tube and shell of the pail, and is, by the curb, prevented from filling up the centre of the pail when the cream can is taken out, so that as many cans can be put in and taken out as may be desired, without repacking the ice.